HEREDITY OF THE CEPHALIC INDEX

DOOR

G. P. FRETS

'S-GRAVENHAGE
MARTINUS NIJHOFF
1924

STELLINGEN.

In einen Satz lässt sich die Wahrheit nicht ausdrücken.
Hegel.

I.

De index cephalicus berust op het bestaan van een veelheid van vormelementen van den schedel, voor welke de mendelistische erfelijkheid geldt.

II.

Voor de vraag, of de normale baring kan plaats vinden, kan het van belang zijn, om den index cephalicus van den vader vast te stellen.

III.

We moeten met Peter (1924) aannemen, dat het secundaire gehemelte tot stand komt, doordat de gehemelteuitsteeksels zich van achteren naar voren langs de tong bewegen, die door de vergrooting van de mondholte naar beneden kan uitwijken.

IV.

Terecht wijzen Berlet (1924) e.a. op de beteekenis van de vaatverzorging voor het ontstaan van ulcus ventriculi.

V.

Voor de diagnose echinococcus verdient het aanbeveling, om de intracutane reactie met hydatiden vloeistof te doen.

VI.

In het ontstaan van haemolytische icterus heeft de milt een groot aandeel.

VII.

De mediale, verticale plooi van het mongolenoog gaat oorspronkelijk niet over in de dekplooi.

VIII.

De poging van Stern—Piper, om Kretschmer's constitutietypen te identificeeren met rastypen leidt niet tot meerder inzicht.

IX.

Men doet goed, om voor de erfelijkheid van dementia praecox en manisch-depressieve psychose multiple allelomorphisme aan te nemen, wat ook Lange (1922) aanduidt.

X.

Op grond van onze tegenwoordige kennis van de aetiologie en de histopathologie behandele men lijders aan multiple sklerose met zilversalvarsan.

XI.

De mendelistische erfelijkheidstheorie geeft geen verklaring voor het ondergaan van eene beschaving.

XII.

De resultaten van de onderzoekingen van Pearson over den invloed van alcoholisme van de ouders op de kinderen hebben geen algemeene waarde.

XIII.

De achturige arbeidsdag voor het verplegend personeel is in het belang van de krankzinnigenverpleging.

HEREDITY OF THE CEPHALIC INDEX

HEREDITY OF THE CEPHALIC INDEX

PROEFSCHRIFT TER VERKRIJGING VAN DEN GRAAD VAN DOCTOR IN DE GENEESKUNDE AAN DE UNIVERSITEIT VAN AMSTERDAM OP GEZAG VAN DEN RECTOR MAGNIFICUS DR. O. LANZ, HOOGLEERAAR IN DE FACULTEIT DER GENEESKUNDE, IN HET OPENBAAR TE VERDEDIGEN IN DE AULA DER UNIVERSITEIT OP MAANDAG 3 NOVEMBER 1924 DES NAMIDDAGS TE 4 UUR

DOOR

GERRIT PIETER FRETS

ARTS, GEBOREN TE BOSKOOP

'S-GRAVENHAGE
MARTINUS NIJHOFF
1924

Aan
Mr. JACOB ISRAËL DE HAAN
gestorven te Jeruzalem 30 Juni 1924

Door de wet LIMBURG *daartoe in de gelegenheid gesteld, bied ik hier, achttien jaar na mijn artsexamen, mijn proefschrift aan.*

Allen, in het binnen- en in het buitenland, die tot mijn wetenschappelijke vorming hebben bijgedragen, ben ik daarvoor dankbaar. In het bizonder U, hooggeschatten Promotor, Prof. Kleiweg de Zwaan, die mij hebt opgewekt, om mijne onderzoekingen over de erfelijkheid van den hoofdvorm tot proefschrift te bewerken.

CONTENTS

	pag.
INTRODUCTION	1
CHAPTER I. DATA FOR A MENDELIAN SCHEME OF HEREDITY FOR THE HEADFORM	6
CHAPTER II. CLASSIFICATION	21
CHAPTER III. THE DIFFERENT MATINGS	29
CHAPTER IV. INDEX AND SEX	48
CHAPTER V. DISCUSSION AND CONCLUSIONS	68
SUMMARY	79
LITERATURE	81
TABLES.	84
ADDENDA OF FAMILIES THAT DO NOT OCCUR IN THE TABLES OF 1921c	90

INTRODUCTION

De natuur is werkelijke denkbaarheid.

BOLLAND.

Wo das Rechnen anfängt, hört das Verstehen auf.

SCHOPENHAUER.

In a previous paper (1921 c) I investigated how far in the material phenomena of mendelian heredity could be fixed. So I examined whether there are phenomena of segregation, of dominance, of heredity according to multiple factors, a. s. o. Segregation and dominance were found. Also was found that there are two forms of brachycephaly which have a different heredity. Phenomena of selection and prepotency were also observed (1921 c, p. 16, 41, 44.).Also in series of indices, one single index sometimes greatly deviates, generally in an upward direction, such a case often occurs in a youngest and last child [1]) (1921 c, p. 31).

In the present paper I have been trying, availing myself of the results of my previous researches (1917—1922), to project a mendelian scheme of heredity and apply it to the different families of my material. In drawing up this scheme the following considerations were of importance.

In studying the heredity of the headform I often raised the question whether the heredity of headlength and headbreadth had to be examined each in itself, or only of the index (1919, pp. 354, 1921 c, p. 4).

One might think both could be done. So I made an examination of

---

[1]) In connection with this question, it may be observed that of children with mongoloid idiotism is stated: "small child, very high index and often last child" LEWANDOWSKY, (1912). See also E. SCHLESINGER (1923) "... unter den schwach begabten Kindern ist regelmässig ein grösserer Prozentsatz von Kindern, die am Ende einer längeren Geburtenreihe stehen; weit steht oft auch das letztgeborene Kind in geistiger Hinsicht hinter allen seinen Geschwistern."

the heredity of the headlength and of the headbreadth, which I considered as a touch-stone with respect to the polymery-theory (1920) [1]).

In this examination I accepted that the heterozygotes of headlength

---

[1]) In this study has been investigated, whether the number of factors of heredity which must be assumed for the explanation of the heredity of the headlength and the headbreadth in the families of the whole material, does not exceed the number of factors necessary for the formulae of heredity of the extreme values of the dimensions of head, as these are known in the anthropological literature. On account of different considerations it is assumed that each factor of length in male gives an increase of the headlength of 0.4 cm., in female of 0.38 cm. For the headbreadth there are assumed values which have connection with those for the headlength. Of all families the formulae for the heredity have been determined. Of special importance are those families where both parents have large, respectively small dimensions of head. For such parents we would assume the presence, respectively the absence of many factors of heredity in a homozygous form. In case that in such families also children occur with very small, respectively very large dimensions of head, we must assume in their parents many factors of heredity in a heterozygous form. By this we come for the material to the assumption of a large number of factors of heredity. Also cases where one of the parents has a very large, or a very small headlength, respectively headbreadth, may give difficulties for the explanation. In these cases the dimensions of head of the children will not be much smaller or larger than those of the second of the parents (1920, p. 125).

The investigation has taught us, that for all families the explanation of the heredity within the limits of the assumptions is possible. On the other hand we sometimes find extreme combinations in some children in one family; a similar coincidence the rules of probability do not admit. The heredity of the headlength may be explained by the effect of a dozen of equal factors. This number is still smaller than the extreme number, that can be calculated from the extreme values of the dimensions of head which are communicated in the anthropological literature. The material however admits of a large possibility of explanation. Generally speaking the result is that the size of the dimensions of head of the children corresponds with those of the parents (1921 b, p. 957).

Theoretically the improbality, that the heredity of the headform is determined by multiple factors for the headlength and the headbreadth, may appear from the following example. If both parents possess all (or a great many) factors in the heterozygous form, for the length as well as for the breadth, we can calculate for the children indices, that are in fact not met with. If we accept e. g. for both parents the formula 12 L l 12 B b, among the indices of the children the formulae 12 LL 12 bb and 12 ll 12 BB may occur, they are the indices 60 and 100 (cf. 1920, p. 126: if we accept one L-factor = 0.4 cm., one B-factor = 0.32 cm., the result will be 12 LL = 17.1 + 12 × 0.4 = 21.9 cm., 12 bb = 13.3 cm., thus I = 60; likewise 12 ll = 17.1 cm, and 12 BB = 13.3 + 12 × 0.32 = 17.14 cm., thus I = 100).

and headbreadth are intermediate. I did so on account of my experience (1920, p. 134; 1921 c, tab. 14 a, p. 47.), that the variability of the dimensions of head of children from parents with large dimensions of head does not differ from that of children from parents with small dimensions of head [1]).

Afterwards, examining the index, I found (1921 c) that the high index (brachycephaly) under certain circumstances is more or less dominant over the low index (dolichocephaly). So the index, although being a compound character, with the understanding that it is not measurable (1921 c, p. 4), is a character in which a heredity-factor finds its basis [2]).

This result changes the value of our examination on the headlength and the headbreadth (1920). If brachycephaly is dominant to dolichocephaly, the heredity of the dimensions of head cannot at the same time be explained by multiple factors that are intermediate in a heterozygous form (sec also 1920 ,p. 125).

---

[1]) As the calculation of the variability of the dimensions of head of children of different parental classes was not entirely satisfying, I give here a new table (tab. a and tab. b. p. 84, 85), in which tables the sons and the daughters have been kept separate and where the classes increase by 1 mm. Class 1 contains the families, where both parents have headlengths, respectively headbreadths 0 cm. above the average value. As such we have taken for the parents 0 and 0,0 and — 0.1 and 0 and + 0.1 cm. For class 2, containing the families, where the headlengths, respectively the headbreadths of the parents are 0.1 cm. longer than the average value, we took for the parents 0.1 and 0.1, 0.2 and 0.1 and 0,3 and 0.3 and — 0.1 cm. In none of the classes the difference of the dimensions of head of the parents has been taken larger than 0.5 cm.

These tables of the dimensions of head are less correct than thase of the indices (1921 c, p. 50), because the indices of children are soon constant (1922, p. 497), the dimensions of head however grow and for each age the dimensions had to be compared with an average of a relatively small number of observations, which moreover in the younger ages represent a large period of growth (one year).

Of the new tables a and b the results are also irregular. In each case they do not teach us, that the variability of the children from parents with mediocrely large dimensions of head is larger than from parents with small or large dimensions of head. Nor do we learn from it that the variability of the dimensions of head of children from parents with large dimensions of head is larger than that of children from parents with small dimensions of head (p. 12).

[2]) As a supplement of previous investigations 1921 a) might serve the calculation of the heredity as correlation of the index of children and parents for brachycephalic and for dolichocephalic parents.

That a similar heredity of the dimensions of head cannot in all cases pretend dominance of brachycephaly, may appear by supposing the theoretical case, that of parents who are brachycephalic, respectively dolichocephalic, all factors for the length and for the breadth occur in the homozygous form. E. g.

Father	×	Mother.
L	20.3	18.8
B	15	15.6
Ind	74	83

For these dimensions we may draw up the following formulae. (We found for the average headlength of male 19.3 cm. i. e. 2.2 cm more than the smallest dimension of head in our material. One factor of length gives an increase of length of 0.4 cm. For females and for the headbreadth corresponding figures may be applied, 1920):

Father L 1 + 2.2 = 3.2 cm. Form. 8 LL (8 × 0.4 cm).
Mother L 0.5 + 2 = 2.5 cm. Form 6 LL (6 × 0.38 cm.).
Father B — 0.3 + 2 = 1.7 cm. Form 4 BB.
Mother B 0.8 + 2 = 2.8 cm.Form. 8 BB.

In this theoretic case, the dimensions of which are exclusively composed of homozygous factors, the gametes all contain the same factors, and all children have the same combination of factors. viz: L = 6 LL 2 Ll and B = 4 BB 4 Bb. The heterozygotes being intermediate, these formulae give for the dimensions of head of the sons L = 19.9, B = 15.7 (for the girls the values are somewhat smaller) and the index = 80. In a similar case therefore seeming dominance of brachycephaly to dolichocephaly by a combination of factors for the dimensions of head cannot present itself.

Our investigation (1920) did not give, as has been said, insurpassible difficulties for the explanation. This was much promoted by the fact, that we had only in few families to dispose of at most three generations, so that we had great possibility to assume formulae and because the most rare combinations of factors for both parents, would not likely occur in our material. Therefore we could always choose the formulae, viz. the number of factors in homozygous and heterozygous form in such a manner, that the explanation was possible, Some times however we found some rare dimensions in one family, more times than the rules of possibility admit of. (1920 pp. 126, 127).

Therefore, by applying the polymerytheory to the dimensions of head, it cannot be explained that from parents in whom all factors for

the headlength and for the head breadth in a homozygous form are present, all children are dominantly brachycephalic.

That the more oval (dolichocephalic) or more round (brachycephalic) headform is a character of the head, also appears from the correlations of index and headlength, respectively headbreadth and the regular differences of those correlations for sex and race (1922, p. 51). These correlations give some idea of the mechanism by which the headform is brought about, i. e, the factors of compensational growth and of race and sex.

For the index we found a number of families where the indices of the children surpassed those of the parents upwards and downwards (1921 c. tables II and III). With respect to the headlength and the headbreadth, we do not find similar families. The reason of this is, that children from physiological (resp. pathological) causes, are sometimes small-headed or big-headed and because index-differences arise in different ways, e. g. by larger breadth and especially smaller height and by larger breadth and especially smaller length (1922. p. 511). In families where the headsizes of parents and children differ little and where non-hereditary modifications are absent, instances with a direct relation between indices and dimensions of head may occur.

This result of the study on our material so far obtained, that for the heredity of the headform independent heredity-units for the dimensions of head cannot be accepted, but that we must resort to factors for the index, has also a general significance. For instance for the heredity of diseases. Here we must also take into consideration that examining the heredity of a given disease, we are not free to accept independent factors for the symptoms, as well as one or more factors for the disease. As there are e. g. investigations on the heredity of dementia praecox, manisch-depressive psychose (RUDIN a. o.) as an independent disease and with that also investigations on the heredity of nomadism, violent temper and other characteristics (DAVENPORT) which occur also as symptoms in the said diseases. Both methods cannot be correct at the same time (1923).

CHAPTER I

DATA FOR A MENDELIAN SCHEME OF HEREDITY FOR THE HEADFORM

We know that the high index is more or less dominant to the low and that the sum of headlength and headbreadth is hereby of importance; in some cases dolichocephaly is dominant to microbrachycephaly. There are also hereditary variations; the indices of children from parents with high indices are also high, those of children from parents with low indices low (1921 c. tab. XV p. 182, tab. 15a, p. 50; 1921 b, p. 965, 966). There is a correlation between the index of the parents and that of the children (1921*a*). In general we will therefore try to explain the heredity of the index on the ground of the polymery-theory, so of multiple factors with dominance.

Now that we assume for the explanation multiple factors with dominance, the families for which we assumed prepotency and selection, are still of an other importance [1]).

Is a high index e.g. 85 obtained by the presence of e.g. 10 multiple factors with dominance for brachycephaly and a low index e.g. 70 by the absence of these 10 factors, the mating 10AA × 10aa = 10Aa will give exclusively brachycephalic offspring. In this case the children have about as high an index as one of the parents. Are the formulae of the parents 5Aa5aa and 5aa5Aa, the mating 5Aa5aa × 5aa5Aa = 5Aa5Aa + 5aa5Aa + 5Aa5aa + 5aa5aa will then give an offspring of which the children surpass the indices of the parents in either direction. Are the formulae 5AA5aa and 5aa5AA the result of the mating will then be 5Aa5Aa; so all children surpass the indices of the parents in

---

[1]) SCHREINER (1923, S. 409) has objections to the acceptance of prepotency for the explanation of the heredity of the indices in some families. Prepotency is also by R. GOLDSCHMIDT and by DAVENPORT accepted (1917, p. 873). Using the term prepotency, one admits that not for all phenomena of heredity a mendelian interpretation is possible (p. 69).

an upward direction. And when finally the formulae are 5Aa5Aa × 5Aa5Aa, among the progeny will also the formulae 5aa5Aa, 5Aa5aa and 5aa5aa occur; so the indices of the children will then surpass those of the parents downwards. Moreover reversed dominance will give surpassing in a downward direction.

We find more families where the indices of the children surpass those of the parents in an upward than in a downward direction. (1921*c*, p. 205, 206).

We see by assuming multiple factors with dominance and reversed dominance, that the surpassing of the indices of the parents by those of the children in an upward or downward direction, can also be explained without the assumption of prepotency and selection.

A corresponding example of reversed dominance, as we found for the cephalic index is the dominance of the hornedness in certain breeds of sheep, which WOOD investigated. He found this character dominant in male and recessive in female individuals. DAVENPORT (1912) has tried to explain the results of WOOD's experiments by sex-linked heredity.

STURTEVANT (1915) elucidates by means of an experiment with Drosophila, the difference between the different dominance in male and female individuals and sex-linked heredity. He had a variation with a slight and another with a dark thorax. From different crosses he deduced whether the character for a light colour would be sex-linked, or dominant in the males and recessive in the females. The following experiment is decisive then. He had a homozygous dark female and a homozygous light male. After the cross he got only dark males and dark females. So here we have sexlinked heredity. Difference of dominance in the male and in the female is also called sex-limited heredity (MORGAN).

GEROULD (1923) describes white wing colour as a sex-limited (sex-controlled) variation in yellow Pierid butterflies.

BATESON (1913), p. 256) moreover points out that phenomena of dominance are zygotic. So in case of modifications in dominance or reversed dominance we mist not doubt of the mendelian segregation but must think that „the peculiarity is evidently zygotic, and is caused either by some feature of zygotic organisation, or by the influence of external circumstances."

As multiple factors we may assume a number of factors acting in the

same direction (NILSSON—EHLE), which each of them has about the same effect. We may however also assume factors with very different effect, so that for instance a very high index in one case is effective by only one factor for that high index, and in a second case by many factors. We may also assume some main factors for brachycephaly and dolichocephaly and in the second place asccessory segregations (Nebenspaltungen, NILSSON—EHLE; residual heredity, CASTLE).

We assume many multiple factors with dominance, which most of them are non-identical, and, mutually differ little; they often pass into groups (in accordance with MORGAN's results with Drosophila). This passing into groups takes, in a way, the place the of assumption of factors of very different values.

Now that we assume dominant factors we should once more look over tab. 15*a*, 1921*c*, p. 242. Here we find a greater variation for indices of children from parents with high and with moderately high indices than from parents with low indices. From parents with moderately high indices the variation of the indices of the children is greater. High indices have factors for brachycephaly in the homozygous or in the heterozygous form (10AA or 10 Aa) moderately high indices have a small number of factors for brachycephaly in the homozygous or in the heterozygous form (5AA5aa or 5Aa5aa) and low indices have a great number of factors for dolichocephaly in the homozygous form (10aa). In order to explain that the variation of the indices of children from parents with moderately high indices is somewhat greater than from parents with high indices, we may assume, that phaenotypically heterozygous brachycephalics have somewhat lower indices yet than homozygous brachycephalics. The very high indices will have many factors then for brachycephaly in a homozygous form and moderately high indices will have many factors for brachycephaly in a heterozygous form.

The head of male is larger than that of female Lm = 19.34, Lf = 18.37, Bm = 15.39, Bf = 14.81 cm. in our material.

The average index of female in our material is higher than that of male (1922, p. 492 and p. 521). We found Im = 80.4 and If = 81.04. This difference we have explained as follows: „the head of female is relatively shorter than that of male and the head of male is relatively wider than that of female; the first difference is greater than the second." We also found that the variation of the index is somewhat

smaller in female than in male. For the present we may take these properties as secondary characters of the sex and thus assume that in each female individual an influence (factor) is active, which effectuates the properties in question [1]). Most likely we shall not be able to explain these peculiarities by sex-linked heredity (p. 48).

Difference in race (1922, p. 519) is likewise most plainly explained by assuming that the multiple factors, constituting the heredity of the index of a race are not identic. Each race has its own factors, that differ little. Crossing of races gives an addition of factors of a different race, so of factors, that differ more. The difference of the factors is a difference of correlation between length, breadth and height (p. 11). Mixture of races is addition of factors of heredity.

According to the results of our investigations I (1922) and II (1921*c*) of the material we may for this third and more specially mendelian research, accept as rules:

1. The index is a hereditary character of the headform (1921*a*).

2. There are hereditary variations of the index (1921*b*, p. 4. tab. I; 1921*c*, p. 242 tab. 15*a*). Therefore we accept many factors. The hereditary variations behave differently; we therefore assume that the factors have a differently great effect by means of the passing of factors into groups (different families, 1921*c*. p. 378, fig. 1*a*—9*a*).

3. There is a high degree of modification (i. e. non-hereditary variation by exterior influences, BAUR). Rachitis, lues, nourishment, youngest and last child, skaphocephaly.

4. There is dominance of the high index to the low. There is also reversed dominance, with respect to the microbrachycephalic head.

5. The negative correlation between headlength and headbreadth is in large heads a little smaller than in small heads (1922 p. 529).

6. The head of female is smaller than that of male (1922. p. 495).

7. The headindex of female is higher than that of male (1922, pp. 511—521).

8. The variation of the index of male is greater than that of female (1922, pp. 482, 494).

9. Perhaps there are also sex-limited heredity of the index and still other influences of sex on the index.

---

[1]) The prime cause for this difference may be the greater body length of male than that of female (see AUERBACH, 1912).

10. The indices of children differ little from those of adults, they are somewhat higher (1922, pp. 497—506).

11. There are differences in race (1922 pp. 511—521).

12. There is prepotency and selection.

To the influences, with which in a special case we may reckon, belong the stature and perhaps the colour of the eyes.

ANDERS RETZIUS, 1842—1860, who brought to light the great significance of the cephalic index as racial character, says as opposed to the objection that the index represents only two dimensions, that experience teaches us that in reality the index may be taken as expression for the headform (1917, p. 439). And in respect of the heredity he points out that — in order to be sure of having to do with the pure type — one has to choose material from the country, and when he disposes of a considerable collection of skulls, e. g. Swedish ones, he selects by a first comparative examination, a few of those that do not show accidental or strange properties. In these two decisions the problem of the index as expression for the headform and of its heredity has already been solved, intuitively, without further analysis.

Later investigations, of BOAS, the Biometric school PEARSON and others, JOHANNSEN make further researches necessary.

PEARSON writes (1911, p. 306): „It would seem unusual to pass over the discussion of the cephalic indices and yet it is doubtful how far they are really indicative for important racial differences", and ORENSTEEN says (1921, p. 17). „the coefficients of correlation resulting from the length and the breadth of the head vary much from one race to another. The significance of this variability is suggestive and the writer accordingly undertook another investigation."

Also my former researches (1921, 1922) contain results in respect of this point.

In drawing up a mendelian scheme, so in choosing the factors of heredity, these two possibilities must be taken into accomt: a. Is the cephalic index the representative character of the headform (a biological relation), for which we may accept a factor of heredity, or b, is the index, a composition of characters having each of them factors of heredity of its own. Another possibility may be that there is a chief factor of the index and that also other factors influence the index.

b. We have already pointed out (p. 1) that we may not accept the dimensions of head as independent factors of heredity.

a. Here we will mention two possible schemes. From my former researches (1916—1921), we know that there are families where brachycephaly is dominant to dolichocephaly, but also some families where dolichocephaly is dominant to brachycephaly. In connection with this varying dominance I have mentioned the headsize [1]). Confirmation of this opinion I found in the fact, that in the material of TOCHER, where all three dimensions of head have been measured, I found that in small heads the negative correlation of L and B is greater than in large heads (1922, p. 529, 530, tab. 26 and 27).

On the ground of these two data we are able to draw up a scheme of the heredity of the cephalic index. Here we meet again with two possibilities: as for the alteration of the headform and those of the headsize, they may arise in two ways.

By alteration of the index, which is brought about as alteration of the dimensions of the head, the headsize may at the same time be altered or the changes of the headsize may be independent of the alteration of the index.

If A increases the breadth, and also the length and the height in a somewhat less degree, the index will become higher and the headsize greater. The effect of A may however be such as to increase the breadth and decrease the length and the height by such a degree, that the index increases by a certain value and the headsize remains unchanged.

We assume that the heredity of the headsize and of the headform take place according to the second manner, that the heredity of the headsize and of the headform are separated. With the heredity of the headsize the heterozygotes are accepted to be intermediate, with that of the headform there exists for the cephalic index varying dominance of brachycephaly to dolichocephaly.

We have not investigated the heredity of the capacity of the head, but most likely it will be intermediate (MAC DOWELL 1914, PHILLIPS

[1]) I pointed out (1922, p. 509) that I know the size of my material only in as much as L + B indicates the headsize. In this examination I speak, in respect to my material, only of the sum of headlength and headbreadth. The headsize in my material I do not know, at least not in an individual case, as the height of the head has not been measured.

1912, 1914, PHILIPTSCHENKO, 1917) [1]). From our investigation of the variability of L + B of the children from parents, L + B of whom is small, mediocrely great and great, does not appear that the variability of parents, L + B of whom is mediocrely great, is greatest (1921*c*, p. 239). Neither did a later and more accurate investigation, in which of sons and daughters the variability was determined separately, yield any other result. There is here much non-hereditary variability. See also p. 73, 74. Similar investigations in respect of the polymery theory are still wanting.

Now, for the heredity of the cephalic index, two schemes may be drawn up, as has been said. According to the first scheme we take the cephalic index as a character for which a factor of heredity exists and set out an allelomorphic pair for brachycephaly and dolichocephaly.

As regards the factors of heredity of the first scheme, on the ground 1. of the dominance found of brachycephaly in heads where L + B is large and the recessiveness in heads where L + B is small and 2. in connection with the different correlations of headlength and headbreadth in large and in small heads we assume that pairs of factors A and B are present in large heads and that in small heads these are changed into pairs of factors C and D. The factors A and B and C and D are two allelomorphic pairs of factors.

They are the same factors which have a different influence on large and on small heads. To point ont this difference in the formulae, we give to the factors in the two cases a different letter. It is necessary for this scheme that there are as many factors for the headsize as for the headform. This is very acceptable if we consider the significance of form and size for each other.

The factors A are factors for macrobrachycephaly and dominant to the factors B for macrodolichocephaly. Each factor A makes the index higher and each factor B makes the index lower by 1.5 units. By the effect of the factor A the head grows wider, lower and shorter, but more lower than shorter. By the effect of the factor B the head grows larger, lower and narrower, but more lower than narrower (1922, p. 523—531).

The factors C are factors for microbrachycephaly, and recessive

---

[1]) SCHREINER 1923. p. 398 thinks on the ground of an examination of my material, that to the factors or at least to some of the factors increasing the size of the head, some dominance must be attributed.

with respect to the factors D for microdolichocephaly. Each factor C makes the index higher, each factor D makes the index lower by 2 units. By the effect of the factor C the head grows wider, shorter and lower, but more shorter than lower. By the effect of the factor D the head grows longer, narrower and lower, but more narrower than lower (1922, p. 528). As the factors C and D make the head wider and especially shorter, respectively longer and especially narrower, while the factors A and B make it wider and especially lower respectively longer and especially lower it is obvious that the change of the length-breadth index by the factors C and D is greater than by the factors A and B.

We accept that the factors are not indentical (p. 8), but differ little. For the sake of simplicity in drawing up the formulas we adopt them to have an equal effect.

The effect of the pairs of factors A and B occurs in large, that of the pairs of factors C and D in small heads so the unions of factors A and B co-operate with unions of factors I and I that make the head larger and the unions of factors C and D with ii's that make the head smaller. This adoption is, as has already been said, based on the experience that macrobrachycephaly is dominant to macrodolicho-cephaly, while microbrachycephaly is recessive with respect to microdolichocephaly and on the fact that in large heads the correlation of L and B is greater (less strong negative) than in small heads. Likewise in accordance with our adoption is, that of a given population large heads have the same indices as small heads. There is no sensible correlation between index and capacity (1922, p. 528) [1]). Large heads are especially composed of A and B factors, small heads especially of C and D factors, high and low indices occur equally on either basis. (p. 000). The index i.e. the headform maintains itself in small heads in a somewhat different way as in large heads (1922, p. 529). This appears from the correlations. In other races again other correlations are found (1922, p. 511).

---

[1]) In fact we find, 1922. p. 527, $r_m = -0.036$ and $r_f = -0.0235$. Formerly 1921 c. p. 248, we found that the heads with high indices are on an average somewhat smaller than those with low indices; for the male $(L + B)_h = 34.67$ and $(L + B)_f = 34.87$ cm, for the female 33.01 and 33.14 cm. These results agree. It is possible, that L + B of heads with high indices and of those with low indices are not quite in the same way a standard for the headsize (p. 18). We found (1922, p. 499) the index of children a little higher than that of adults. So did Bryn (1920, p. 199).

As the average index of female is greater than that of male we can accept for the present, as has been said (p. 9), that as a secondary character of sex there is an influence that makes the index of the female (so each term in the formula) a little higher than that of the male (p. 48). In drawing up the formulae we have thought it sufficient to diminish the indices by the difference of the average index of male and of female. (p. 29).

We adopt a great number, nineteen, multiple factors for the heredity of the index. This number is arbitrary, but we choose it because the indices and the dimensions of head of a good deal of the material have a relatively small range of variation: So, for instance, of half the material the indices lie between 82 and 78 (GALTON's quartils 1922, p. 482), while the range of the whole material amounts to 95—65 thus 30 units.

To make a similar altered effect of factors A and B, and C and D, clear to ourselves, is not easy. It is a phenomenon in the zygote (p. 7), but we do not know, what dominance is. The factors for the headsize being intermediate we will accept that the change of effect of A and B into C and D is brought about when these factors come together in a zygote with Ir and with Ii. Then is attained, that there are in the formulas more A, resp. B terms than C, resp. D terms.

The application of this first scheme takes place in the following way:

In our material we know only L and B, so for the determination of the headsize we can only avail ourselves of these dimensions (p. 11). We begin by drawing up the formula for the headsize. By means of the headsizes of the children and those of the parents (and if we know them also of those of the grandparents and brothers and sisters of the parents) we draw up a formula and determine in this way the numner of II's, Ii's and ii's, for the headsizes. The number of II's and Ii's in each headzise indicates the number of A, respectively B factors, the number of ii's the number of C, respectively D factors. The formula for the indices we determine by means of the indices of the parents and children [1]) (p. 30). So in this hypothesis it is obvious that reversed dominance is a phenomenon in the zygote. It is also dependent on

[1]) In some cases we make a correction. When there are in the formula 3 CC's more than DD (or CD)'s, these 3 CC make the index 3 × (2 — 1.5) = 1.5 index units higher than when 3 AA were present. In such a case we choose in the formula 1 AA less than the number that tab. h indicates. When there are 3 DD's more than BB's we choose 1 BB less than the number in tab. h.

modification. When a II term is modified during growth and remains for instance very small, than this will have its influence on the index AA will approach to CC, Ab to CD.

We shall give examples in the next chapter of this paper. There are however objections to this scheme, and these objections lead us to a 2nd scheme. The scheme dealt with just now, is based on the assumption that the index is a simple character, the characteristic property for the headform. The study on the cephalic index however leads to an analysis of the head index. We have already cited the uncertain point of view of PEARSON (p. 10). As a result of the study on the correlation of the dimensions of head and of the study of the heredity of the index, the following second scheme may be drawn up.

Of a pair of factors A and a, factor A increases the headbreadth by a certain amount, and decreases the headlength and height by smaller amounts; factor a decreases the headbreadth by the same amount, and increases the headlength and height by smaller amounts.

Of a pair of factors B and b, factor B increass e the headlength by a certain amount and decreases the headbreadth and height by smaller amounts; factor b decreases the headlength by the same amount and increases the headbreadth and height by smaller amounts.

Of a pair of factors C and c, factor C increases the height by a certain amount and decreases the length and height by smaller amounts; factor c decreases the headheight by the same amount and increases the length and, the breadth by smaller amounts.

It is possible that the effect of the pairs of factors in large heads is somewhat different from that in small heads. In this case there are still factors A_1 and a_1, B_1 and b_1, C_1 and c_1.

The factors are non-identical. The number of factors A and a, B and b, C and c will be different. The total number of pairs of factors A and a, B and b, c and C, we accept to be as large as the number of factors for the headsize.

The advantages of this scheme consist of its being complete and its answering to the requirements of the presence-absence theory. Besides the length-breadth index, there occur also in this scheme the length-height index and the breadth-height index. Each factor has a chief effect on one index and secondary effects on the two other indices. In general this has been represented in tab. *c* and for special but arbitrary values in tab. *d*.

Tab. *c*.

	Factors.	Breadth.	Length.	Height.	BL index.	HL index.	HB index.
Large heads.	A	+ + +	—	— —	+ +	—	— — —
	a	— — —	+	+ +	— —	+	+ + +
	B	—	+ + +	— —	— —	— — —	—
	b	+	— — —	+ +	+ +	+ + +	+
	C	—	— —	+ + +	+	+ + +	+ +
	c	+	+ +	— — —	—	— — —	— —
Small heads,	A1	+ + +	— —	—	+ + +	+	— —
	a1	— — —	+ +	+	— — —	—	+ +
	B1	— —	+ + +	—	— — —	— —	+
	b1	+ +	— — —	+	+ + +	+ +	—
	C1	— —	—	+ + +	—	+ +	+ + +
	c1	+ +	+	— — —	+	— —	— — —

Tab. *d*.

	B.	L.	H.	Index.
A	+ 3.5	— 1	< — 2.5	+ 2
a	— 3.5	+ 1	> + 2.5	— 2
B	— 1.5	+ 4	< — 2.5	— 2.5
b	+ 1.5	— 4	> + 2.5	+ 2.5
C	— 1	— 2	> + 3	+ 1
c	+ 1	+ 2	< — 3	— 1

The chief effect of factor A consists in its increasing the length-breadth index, of a in its decreasing this index. A gives brachycephaly and is dominant to a, giving dolichocephaly. The presence-factor is dominant to the absence-factor.

The chief effect of B consists in its decreasing the length-breadth index, of b in its increasing this index. B gives dolichocephaly and is dominant to b ,giving brachycephaly. The presence-factor is dominant to the absence-factor.

A secondary effect of C is, that the length-breadth index increases, of c that this index decreases. C gives as secondary effect brachycephaly, of which is to be investigated whether it is dominant to c yielding dolichocephaly. Then the presence-factor is dominant to the absence-factor.

As already has been said, this second scheme is of importance because it is complete and has been drawn up as a pure mendelian scheme. It is obvious that factor a decreases the index by the same amount as by which A increases the index; a is the absence of A. Likewise B and b, C and c.

This is not so clear in our first scheme. In our first scheme it must be accepted emphatically that A, which increases the index by a certain value, so that the breadth becomes greater, and the length and especially the height smaller, has as great an effect as B, which decreases the index, so that the length becomes greater and the breadth and especially the height smaller.

As in my material only L and B have been measured, the second scheme cannot be applied to it. Yet we can test it, in a way, to our material.

According to the 2nd scheme (tab. *d*) the factor A for brachycephaly in the dominant form, will increase the sum of length and breadth in our assumption, by 2.5 mm. The factor b giving also brachycephaly, but in the recessive form, will decrease the sum of L and B in our scheme, by 2.5 mm. So A increases L + B, b decreases L + B. In this sense we may call A a factor for macrobrachycephaly and b a factor for microbrachycephaly. Likewise factor B for dolichocephaly in the dominant form increases L + B by 2.5 mm. and a for dolichocephaly in the recessive form decreases L + B by 2.5 mm. So B may be called a factor for macrodolichocephaly and a a factor for microdolichocephaly. In this scheme A is dominant to a, so macrobrachycephaly dominant to microdolichocephaly. Likewise B dominant to b, so macrodolichocephaly to microbrachycephaly.

The factor C which, as secondary effect, increases the length-breadth index and so is a factor for brachycephaly in the dominant form as we assume, decreases the sum of L and B by 3 mm.

The factor c as secondary effect decreases the length-breadth index, and so is a factor for dolichocephaly, increases L + B by 3 mm. We expect C as presence-factor to be dominant to c. Then as secondary effect of C and c, microbrachycephaly is dominant to macrodolichocephaly. There is nothing contradictory to this, for in respect of the length and the breadth, C is a repression-factor.

What may attract us in the second scheme is, that the alterations of the indices arise in two ways. As an effect of the macro-factor (A) bra-

chycephaly arises by increasing of the breadth, as an effect of the micro-factor (b) brachycephaly arises by decreasing of the length. Likewise dolichocephaly exists in two ways, by B and by a.

Also in other processes results are obtained in two ways. E.g. the N. vagus acts on the heart as inhibitor, the N. sympathicus as accelerans. An increase of the frequency of the pulse takes place by paralysis of the n. vagus and by excitation of the n. accelerans.

As the headform is an important property, it is an advantage of the 2nd scheme that alterations in the indices arise in two ways.

The application of the 2 nd. scheme must be put off till material will be collected of family investigations in which the length, the breadth and the height have been measured. The formula for the index will be determined then in connection with the headsize.

The value of each dimension is determined by the headsize and by the headform. Of large heads all dimensions will be large. The different headforms cause a change in the mutual proportions of the dimensions. So the values of the dimensions are in the first place determined by the factors I and i for the headsize, only in the 2 nd place by the factors A and a, B and b, C and c, which are factors for the headform.

The way to follow will probably be a reduction of the headsize to a mean, a normalized headsize. The dimensions of head of normalized headsizes are mutually comparable in respect of the presence of the number of A, B and C, resp. a, b and c, factors.

As our material contains only the length and the breadth of the dimensions of head we shall keep ourselves from trying the further application of the 2nd scheme. However we are able to indicate in our material the effect of the second scheme.

The factor A, as has already been said, increases L + B, and so does the factor B. In cases where L + B is great, there is therefore the probability that brachycephaly is especially caused by the factor A, and dolichocephaly by the factor B. We do not know it for certain because we have not normalized the headsize. Likewise we will accept the factor b for brachycephaly and a for dolichocephaly, especially when L + B is small.

Further if in a series of children, all being brachycephalic, of one of the children, though having also a high index, the headlength is suddenly found to be much smaller than that of the other children, we will

think here brachycephaly to be caused by bb, so e.g. arisen from the segregation Bb × Bb in the parents.

Also in the mutual comparison of the breadths there may be found indications for the factors of the headform, which in the first place change the breadth. As we do not know the headsize, we cannot draw up the complete formulas.

According to both schemes the sum of the headlength and the headbreadth is of importance. According to the first scheme L + B is an indication for us of the headsize and so of the presence of the factors A and B, C and D, according to the 2nd scheme L + B gives us an indication for the presence of the factors A and B, respectively a and b.

Also in the 2nd scheme we may take account of the influence of the headsize on the index as we have accepted according to the 1st scheme (p. 12).

While the second scheme as mendelian scheme will satisfy more than the first, yet it has some properties to which our material does not answer.

The factor A is a factor of dominance for the headbreadth, gives brachycephaly and increases L + B, the factor B is a factor of dominance for the headlength and for dolichocephaly and also increases L + B.

Likewise the factors a and b are factors of recessiveness for dolichocephaly and brachycephaly. (We have not examined the factors C and c).

Now we find in our material (1921*c*, tab. 15*a*, p. 242) more families with dominance of brachycephaly than with recessiveness of it and the variability of children from parents with brachycephalic indices we find greater than that of children from parents with dolichocephalic indices.

If this difference is of significance, and that is my opinion, we must therefore accept that, if the heredity of the index acts according to the 2nd scheme, there occur more A and a than B and b factors. It is of importance in this respect that the stray communications on the heredity of the cephalic index always contain that brachycephaly is dominant to dolichocephaly.

So we must accept that the factors A and a occur more frequently than the factors B and b. Therefore brachycephaly is oftener caused by AA and Aa than by bb and dolichocephaly oftener by aa than by

BB and Bb. Under these circumstances the variability of the indices of children from parents with brachycephalic indices will be greater than of children from parents with dolichocephalic indices and cases of dominance of dolichocephaly to brachycephaly (BB to bb) seldom occur then.

If we accept that the factors A and a occur oftener than the factors B and b (we have no data about C and c), we would expect, as A influences the breadth more strongly than the length, that the variability of the headbreadth would be greater than of the headlength. This, indeed, TSCHEPOURKOWSKY (1905, p. 290) mentions. He writes that the varieties of the human headform are mostly owing to the variation of the breadth. In my material (1922, p. 495), both in males and females, the standard deviation of the length is greater than that of the breadth, the coefficient of the variation is in males and females somewhat smaller for the length than for the breadth.

For further knowledge of the index and its heredity, material for family-investigations, in which all 3 dimensions of head are determined must be waited for.

The two schemes are much in accordance in respect of their application. The factors A and B of the first scheme agree with A and a of the 2nd scheme, and in a way also C and D of the first scheme with B and b of the 2nd scheme. Also of the factors C and D (1. scheme) the decrease, respectively increase of the length is greater than of the factors A and B (1 scheme), as is the case with the factors b and B (2nd scheme) and a and A (2nd scheme). Where we introduce the factor C, we also express in the formula, as has been said, that the headlength is small in this case, accepting that each factor C increases the index with 2 units (p. 12, 13). In the 2nd scheme, however, these differences are expressed better.

CHAPTER II

CLASSIFICATION

In order to render it accessible to our research in the best way, we have grouped the material in tables, so that, in as much as this is possible, we have in each table to do with corresponding cases. Of the different cases of each table we can take into consideration the peculiarities and define whether it is really a simple case.

As there are many difficulties connected with the investigation of the headform (1919, p. 351—353) still working in this way, each table, even though it contains some more deviating cases, will show us some simple instances.

So with a view to the phenomenon of dominance we wish to form groups in which both parents have high, respectively low indices and a group in which one of the parents has a high and the other a low index.

We discriminate brachycephalic × brachycephalic, dolichocephalic × dolichocephalic and brachycephalic × dolichcephalic. As there are hereditary variations of the index, we have, properly speaking to do with differently high indices as soon as the indices differ the value of a heredity factor (i.e. 1.5 index-units). In order to take this fact into consideration, we examine in each family of a table, whether it exactly answers to the definition of the table.

For this third treatment of the material we have grouped it according to index, to the value of L + B and to sex, and so we obtain the tables: macrobrachy - × macrobrachycephalic, macrobrachy- × microbrachycephalic, microbrachy- × macrobrachycephalic, a.s.o. [1]). On each table are first ranged the cases which entirely answer to the definition, starting from the highest value of L + B of the mother.

[1]) With crossings the mother, as customary, is mentioned in the first place. On the other hand, it is true, in the columns of the tables the father has been placed before the mother.

Then the cases follow for which the definition cannot be applied to L + B, after that follow those for which the definition is not applicable to the index. For the mean value of L + B we have taken the average headlength and the average headbreadth of our material. (1922, p. 495 i.e. for the male L = 19.34, B 15.39, L + B = 34.73 or 34.6 and for the female L = 18.37, B = 14.81, L + B = 33.18 or 33.1). We know that L + B is only an indication for the headsize (1922, p. 506); cf. also BOLK (1920).

In this examination we call heads to be of the same size and indices of the same value, if L + B do not differ more than 0.5 cm. and indices not more than 1.5 index-units (p. 12 and 87).

In the tables 1—74 the index of the female has not been reduced. So the tables in which the mother is brachycephalic, contain families which by introducing the reduced index of the mother should have to be transported to other tables.

The material consists of 405 families with 772 sons and 878 daughters = 1650 children [1]).

I. Both parents have large heads. 19 tables (1—19) 151 families, 261 sons and 332 daughters = 593 children.

II. Both parents have small heads. 16 tables (20—35) 82 families, 163 sons and 188 daughters = 351 children.

That the number of families where both parents have small heads, is so much smaller than the number of families, where both parents have large heads, is partly due to the fact that we have taken the average value for the sum, of headlength and headbreadth for the male as well as for the female somewhat too small. We found for the male (1922, p. 495) L + B = 19.34 + 15.4 = 34.74 and for the female 18.36 + 14.8 = 33.16 and we have taken 19.3 + 15.3 = 34.6 and 18.3 + 14.8 = 33.1.

III. One of the parents has a large head, the other a small head. 39 tables (36—74) 172 families, 348 sons and 358 daughters = 706 children.

So there are 233 families where both parents have large, respectively

---

[1]) The whole material (1922, I, 1921 c, II) consists of about 3600 observations. In this number are also included the incomplete families. There is a casual reason that there are more daughters than sons in this material. Among the visitors of the asylum are more daughters than sons and calling at the families'homes, we will sooner meet with daughters than with sons.

small heads and 172 families where one of the parents has a large head and the other a small head. So with respect to the headsize (which bears relation to the length of the body), our material also confirms the rule that there is a preference for the assortative mating. (PEARSON, DAVENPORT).

We get the following

Sub-Classification

I. 1. The parents are brachycephalic and dolichocephalic or the contrary. 10 tables (1—10) 76 families, 133 sons and 178 daughters = 311 children.

a. The mother is brachycephalic and the father dolichocephalic. 5 tables (1—5) 45 families, 81 sons and 109 daughters = 190 children. We do not publish these tables, but only give a list of the families, that each table contain. The families may be found in my publication Heredity of Headform in Man, 1921c p. 66 (258)—175 (367) and in the addenda of this paper.

Tab. 1, Fam. 167, 226, 243, 216k, 182b, 304, 199, 57b, 285a. Tab. 2, Fam. 36b, 378, 324i, 245a, 88, 277, 232b, 16c, 198. Tab. 3, Fam. 182d, 16a, 82c, 68, 182e, 22, 177l, 34b. Tab. 4, 271a, 323, 53b, 23, 32f, 380a, 73c, 339a, 179f, 335, 32g, 366. Tab. 5, Fam. 216q, 288, 216p, 76, 362, 240, 257aa, 107, 337a.

b. The mother is dolichocephalic and the father brachycephalic. 5 tables (6—10) 31 families 52 sons and 69 daughters = 121 children. Tab. 6, fam. 308, 202a, 221, 177n, 327, 242. Tab. 7, fam. 380d, 84a, 366a, 302, 335a, 177 p.Tab. 8, fam. 257, 177c, 22b, 245, 378b, 350, 324h, 380e, 293. Tab. 9, fam. 380b, 71, 13, 324a, 377, 216j. Tab. 10, fam. 160, 298b, 240e, 286c, 216c, 367a, 298a.

I. 2. Both parents are brachycephalic, resp. dolichocephalic. 9 tales (11—19) 75 families, 128 sons and 154 daughters = 282 children.

c. Both parents are brachycephalic. 4 tables (11—14) 47 families, 78 sons and 91 daughters = 169 children. Tab. 11, fam. 67, 3f, 22a, 3n, 240b, 177e, 223, 379e, 177ee, 90a, 123, 20a. Tab. 12,fam. 217, 177d, 324d, 152e, 3a, 62, 3p, 165, 18b, 234, 354, 203a. Tab. 13, fam. 177dd, 177cc, 177, 177b, 175, 82, 348, 378a, 248, 320, 95, 22dd, 177f. Tab. 14, fam. 22c, 53, 324, 379b, 28, 182f, 15, 131a, 376, 90.

d. Both parents are dolichocephalic. 5 tables (15—19) 28 families, 50 sons and 63 daughters = 113 children. Tab. 15, fam. 182aa, 34,

322a, 216a, 190a, 78, 236a, 205, 249, 322b, 310. Tab. 16, Fam. 218a, 34a, 366b, 64a, 21, 351, 6, 182. Tab. 17, Fam. 228a, 361, 17a, 268. Tab. 18, Fam. 301, 82a. Tab. 19, Fam. 366d, 57, 148.

We see, that the group I, 1 and I, 2 have about the same numbers of families.

II. 3. The parents are dolichocephalic and brachycephalic or the contrary. 9 tables (20—28) 39 families, 81 sons and 80 daughters = 161 children.

e. The mother is dolichocephalic and the father brachycephalic. 5 tables (20—24) 12 families, 25 sons and 25 daughters = 50 children. Tab. 20, fam. 269a, 256a, 357, 309, 63a. Tab. 21, fam. 337b. Tab. 22, fam. 233, 216d. Tab. 23, fam. 11. Tab. 24, fam. 32c, 30b, 124a.

f. The mother is brachycephalic and the father dolichocephalic. 4 tables (25—28) 27 families, 56 sons and 55 daughters = 111 children. Tab. 25, fam. 88a, 17c, 356c, 377b, 3r, 339c, 136. Tab. 26, fam. 147a, 64, 380h, 356a, 327c. Tab. 27, fam. 47, 105a, 287a, 327b, 271e, 331b, 331. Tab. 28, fam. 182c, 173d, 19, 271c, 215, 301b, 18a, 287, 340.

II. 4. The parents are both dolichocephalic, respectively both brachycephalic. 7 tables (29—35) 43 families, 82 sons and 108 daughters = 190 children.

g. Both parents are dolichocephalic. 3 tables (29—31) 20 families, 36 sons and 49 daughters = 85 children. Tab. 29, fam. 3s, 72b, 164, 319c, 271d, 86, 269. Tab. 30, fam. 41a, 324c, 32, 328c, 372, 14a, 196. Tab. 31, fam. 152d, 183, 30c, 27, 353, 253.

h. Both parents are brachycephalic. 4 tables (32—35) 23 families, 46 sons and 59 daughters = 105 children. Tab. 32, fam. 113, 27a, 331a, 173, 124. Tab. 33, fam. 55, 84b, 179a, 190b, 85a, 288a, 197c, 3c. Tab. 34, fam. 30a, 327a, 57c, 281, 87d, 3d. Tab. 35, fam. 349, 73a, 271, 258.

Here the number of families of the group II, 3 is a little smaller than that of II, 4.

III. 5. The parents are brachycephalic and dolichocephalic or the contrary. 24 tables (36—59) 91 families, 198 sons and 200 daughters = 398 children.

i. The mother is macrobrachycephalic and the father microdolichocephalic. 7 tables (36—42) 32 families, 67 sons and 73 daughters = 140 children. Tab. 36, fam. 216h, 288, 182a, 256b. Tab. 37, fam. 29, 334, 32e, 63, 328a, 17b, 303, 152a. Tab. 38, fam. 355, 1, 19b. Tab. 39,

fam. 82d. Tab. 40, fam. 324g, 85, 197a, 284, 153, 36a, 204. Tab. 41, fam. 285, 73, 3, 188.

j. The mother is microdolichocephalic and the father macrobrachycephalic. 6 tables (43—48) 20 families. 46 sons and 37 daughters = 83 children. Tab. 43, Fam. 89, 324b, 292c. Tab. 44, fam. 363, 176, 44, 194a, 269d. Tab. 45, fam. 70. Tab. 46, 370, 147. Tab. 47, fam. 335c, 32d, 286a, 34e, 217a. Tab. 48, fam. 288b, 245b, 130, 342.

k. The mother is macrodolichocephalic and the father microbrachycephalic. 4 tables (49—52) 7 families, 12 sons and 19 daughters = 31 children. Tab. 49, fam. 3b, 378c. Tab. 50, fam. 180, 179d. Tab. 51, fam. 184, 224. Tab. 52, fam. 173a, 10b.

l. The mother is microbrachycephalic and the father macrodolichocephalic. 7 tables (53—59) 32 families, 73 sons and 71 daughters = 144 children. Tab. 53, fam. 337, 216e, 20. Tab. 54, fam. 147b, 109, 347b, 347a, 239, 216r, 156. Tab. 55, fam. 149, 179b. Tab. 56, fam. 57d, 341, 34c. Tab. 57, fam. 73b, 87e, 12, 319b, 296, 16b, 286b. Tab. 58, fam. 380g, 179e, 17, 328b, 356. Tab. 59, fam. 269c, 216i, 237, 366c, 379c, 377a, 309a.

III. 6. Both parents are brachycephalic, respectibely both are dolichocephalic. 15 tables (60—74) 81 families, 150 sons and 158 daughters = 308 children.

m. The mother is macrobrachycephalic, the father microbrachycephalic. 3 tables (60—62) 23 families, 60 sons and 46 daughters = 106 children. Tab. 60, fam. 3l, 189, 352, 324k. Tab. 61, fam. 192, 291, 10a, 286a, 15a, 222, 66, 380f. Tab. 62, fam. 271b, 209, 365, 5a, 137, 82b, 111, 18, 225, 286, 241, 171.

n. The mother is microbrachycephalic, the father macrobrachycephalic. 4 tables (63—66) 23 families, 32 sons and 43 daughters = 75 children. Tab. 63, fam. 84, 128, 216s, 42a, 197b, 215a. Tab. 64, fam. 3k, 379d, 3m, 173c, 296a, 324e. Tab. 65, fam. 364, 299, 347c. Tab. 66, fam. 87c, 173b, 93a, 379a, 56, 179c, 152c, 72a, 335e.

o. The mother is macrodolichocephalic, the father microdolichocephalic. 5 tables (67—71) 19 families, 39 sons and 38 daughters = 77 children. Tab. 67, fam. 173dd, 39a, 73b, 300, 216f, 80a, 71a, 335d. Tab. 68, fam. 240d, 228. Fab. 69, fam. 292a, 115a. Tab. 70, fam. 22e, 19a, 322, 130a, 324f. Tab. 71, fam. 203, 115c, 318.

p. The mother is microdolichocephalic, the father macrodolichocephalic. 3 tables (72—74) 16 families, 19 sons and 31 daughters = 50

children. Tab. 72, fam. 34d, 335b, 240. Tab. 73, fam. 298, 48, 269b, 240a, 380c, 380j, 216l, 313, 292b, 374. Tab. 74, fam. 80, 216g, 171b, 349a, 144.

We see that in group III, III 5 contains more families than III 6.

In group I the paragraphs a and b, thus 76 families have different headforms, the same headforms have the paragraphs c and d thus 75 families. In group II these figures are 39 and 43 and in group III 91 and 81. Altogether we have in our material 206 families where the parents have different headforms and 199 families where the parents have the same headforms.

Tab. *f*.

Group	Group I Large Headsize				Group II Small Headsize			
Sex	Mothers		Fathers		Mothers		Fathers	
Index	Brachyc	Dolichoc	Brachyc	Dolichoc	Brachyc	Dolichoc	Brachyc	Dolichoc
N	45			45		12	12	
	47		47			20		20
		31	31		27			27
		28		28	23		23	
Total	92	59	78	73	50	32	35	47
Percent(%)	61	39	51.7	48.3	61	39	40	60

As to the headsize, the matings yielded a preference for equal headsizes, this preference is however not found for the index.

As to the appearance of the brachycephalic and the dolichocephalic headform in the mothers and the fathers, we see from table *f*, that under group I, out of 151 families, 92 mothers and 78 fathers are brachycephalic; whilst 59 mothers and 73 fathers are dolichocephalic. Among the mothers are more brachycephalic indices than among the fathers. This difference may thus be explained, that for the mothers we have not introduced the reduced index. Also among the fathers there are some more brachycephalic than dolichocephalic indices. (The difference is slight; the average index of males is 80.4, of adult males 79.6; 1922, p. 483). Under group II we see that the mothers have the same figures of percentage for the brachycephalic and dolichocephalic indi-

ces; among the fathers however there is a considerably smaller number of brachcephalic than of dolichocephalic indices.

From tab. *g* we see, that in group III there are 81 mothers with large heads and 91 with small heads, on the other hand 81 fathers with small heads and 91 with large heads. That we do not meet equal numbers here, depends on our taking the sum of the average headlength and headbreadth for the male (34.6) somewhat more too small yet (34.73) than for the female (31.1 and 33.18). (p. 86).

As for the proportion of the brachycephalic and dolichocephalic indices in group III we see that of the large headsized as well as of the small headsized the mothers yield considerably more brachycephalic than dolichocephalic indices. The figures agree with those of group II and of group I, tab. *f*. For the fathers we find under the small headsized the figures 37 % and 63 %, which do not deviate much from those of group II, which are 40 % and 60 %. For the large headsized we find figures, which deviate somewhat more from those of group I.

Tab. *g*.

Group	Group III Large Headsize				Group III Small Head-size			
Sex	Mothers		Fathers		Mothers		Fathers	
Index	Brachyc	Dolichoc	Brachyc	Dolichoc	Brachyc	Dolichoc	Brachyc	Dolichoc
N	32							32
			20			20		
		7					7	
				32	32			
	23						23	
			23		23			
		19						19
				16		16		
Total	55	26	43	48	55	36	30	51
%	68	32	47.3	52.7	60.4	39.6	37	63

So there appears from tab. *f* and *g*, that among the mothers there are more brachycephalic than dolichocephalic indices; the proportion is for mothers with large heads about the same as for mothers with small

heads. From tab. *f* and *g* it appears that fo the fathers with large heads, there are almost as many brachycephalic as dolichocephalic indices. Of the fathers with small heads the number of brachycephalic indices is much smaller than the number of dolichocephalic indices.

That among the mothers there are more brachycephalic than dolichocephalic indices is in accordance with the fact, that the average index of the mothers is greater than 80, being the limit of brachycephalic and dolichocephalic indices. That the average index of female is greater than that of male is due or partly due to a different correlation of length, breadth and height in male and in female (p. 8, p. 55).

That of the fathers with small heads, in tab. *f* as well as in tab. *g* the number of brachycephalic indices is smaller than the number of dolichocephalic indices, may result from the fact that we have found for the small head recessiveness of brachycephaly. It is remarkable that with the mothers the proportion of brachycephalic and dolichocephalic indices for large and small heads is about the same (p. 48), that here the influence of recessiveness of microbrachycephaly does not present itself.

Of 593 children in group I are 44 % sons and 56 % daughters; of 351 children in group II 46.4 % sons and 53.6 % daughters and in group III of 706 children 49.3 % sons and 50.7 % daughters. The whole material (p. 22) contains 46.8 % sons.

CHAPTER III

THE DIFFERENT MATINGS

Of the tab. 1—74 (p. 17) the formulae of many families have been drawn up according to the first scheme. Different families have also been compared with the requirements of the 2nd scheme. For the present we omit the publication of the description of the different families. For all families it is possible to draw up formulas. The two schemes lead to corresponding results here.

Looking over the 74 tables will give us an impression of the significance of our classification. We see the brachycephalic families, the dolichocephalic families, the dominance of brachycephaly, the recessiveness of brachycephaly, the difference between a crossing and the reciprocal crossing.

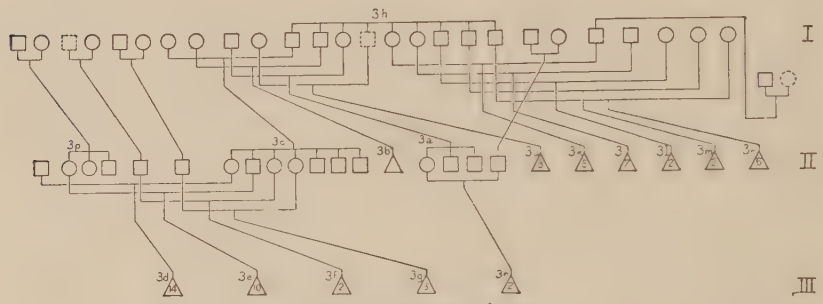
For each table we have determined the mean index and the mean value of L + B of the fathers and of the mothers. The comparison taught us the significance of the heredity of the variations of index and headsize.

According to the first scheme of some families of each table complete formulas have been set out. Of each family for which the formula has been drawn up the number of times that each crossing (AA × AA, CC × CC, BB × BB, AA × BB, a.s.o.) occured, has been noted down. In this way we could state for each table whether the crossing that is characteristic for a table, is indeed a relatively frequent occurence. Likewise we could calculate the number of reversions (AA into CC, AB into CD, a.s.o.) for the different tables.

A good deal of our time we bestowed upon the research of the results of a crossing and the reciprocal crossing. Amongst others we have calculated for all tables where among the children brachycephalic and dolichocephalic indices appear, the number of sons and of daughters with brachycephalic, resp. dolichocephalic indices and these results

have been compared of the tables where the mother is brachycephalic, resp. dolichocephalic with those where the father is brachycephalic, resp. dolichocephalic. We shall deal in another section of this paper (p. 48) with the signifance of the sex for the heredity of the index.

As an example of the application of the first scheme we will draw up here for one family the formulas (p. 14) and take the largest family of our material fam. 3, of which 100 members have been measured.



Fam.3 (104 members)

In drawing up the formulae we have entirely confined ourselves to the requirements of the scheme. So we have first drawn up for each family the formula for the headsize. By this we know how many ii's each member of the family contains, likewise we know how many factors for the headform as CC, respectively DD (or CD) will be present. So we can indicate the number of A, B, C and D factors for the index of all members of the family. While taking down the formula for the index we see to it that each A and B factor gets a place, occupied in the formula for the headsize by II or Ii. Only the ii places are to be occupied by C and D factors (p. 14).

Fam. 3h. Eight brothers and sisters. Index $x \times y = 84.5 + 82.4 + + 80.9 + 80.5 + 83.2|^{1}) + 83.6 + 82.5 + 81.5$. Size: $x \times y = - - 0.1$ [2]) $+ - 0.5 + 0.4 + 1.2 + - 0.1 + 0.5 + - 1 + - 0.1$. Size: $x \times y = 12$ [3]) $+ 11 + 13 + 14 + 12 + 13 + 10 + 12$.

---

[1]) The males and females are separated by a vertical line.

[2]) — 0.1 means 0.1 cm smaller than the average value of L + B, a. s. o.

[3]) Taken from tab. h, cf. p. 87.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M [1])	(II	II	II	II	II	II	II	II	II	II	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii)
F [1])	(II	II	II	II	II	II	II	II	Ii	Ii	II	II	ii	ii	ii	ii	ii	ii	ii)
1								II	II	II	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii
2								II	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii
3								II	II	II	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii
4								II	II	II	II	II	Ii	Ii	Ii	Ii	ii	ii	ii
5								II	II	II	II	II	ii	ii	ii	ii	ii	ii	ii
6								II	Ii	Ii	II	II	Ii	Ii	Ii	Ii	ii	ii	ii
7								II	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii	ii	ii
8								II	Ii	Ii	II	II	ii	ii	Ii	Ii	ii	ii	ii

We find 2II × 2Ii, 2Ii × 2II, and twice 2Ii × ii. Observation 16II; expectation 16II. Observation 14ii and 18Ii; expectation 16ii and 16 Ii.

Index. Formula x × y = 13A14I [2]) + 12A14I + 11A16I + 10A16I + 12A12I + 12A16I + 12A12I + 11A14I.

Formula x × y = 10A3C4B2D + 9A3C5B2D + 9A2C7B1D + + 9A2C7B1D + 8A4C4B3D + 10A2C6B1D + 8A4C4B3D + +8A3C6B2D.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M [3])	(AA	AA	AA	AA	AB	AB	AB	AB	AB	BB	BB	BB	BB	AA	AA	BB	CC	CC	DD)
F [3])	(AA	AA	AB	AB	AA	AB	AB	AB	BB	BB	BB	BB	DD	CC	CC	DD	CC	CC	CD)
1 [4])	AA	AA	AA	AA	AA	AB	AB	AB	AB	BB	BB	BB	BB	AA	CC	DD	CC	CC	CD
2	AA	AA	AA	AA	AB	AB	AB	AB	BB	BB	BB	BB	BB	AA	CC	DD	CC	CC	CD
3	AA	AA	AB	AB	AA	BB	BB	AB	AB	BB	BB	BB	BB	AA	AA	BB	CC	CC	DD
4	AA	AA	AB	AB	AB	BB	BB	AA	AB	BB	BB	BB	BB	AA	AA	BB	CC	CC	DD
5	AA	AA	AB	AB	AB	AB	AA	BB	AB	BB	BB	BB	DD	CC	CC	DD	CC	CC	DD
6	AA	AA	AB	AB	AA	AA	AB	AA	BB	BB	BB	BB	BB	AA	AA	BB	CC	CC	DD
7	AA	AA	AA	AA	AA	AA	AB	AB	BB	BB	BB	BB	DD	CC	CC	DD	CC	CC	CD
8	AA	AA	AA	AA	AB	AB	AB	BB	BB	BB	BB	BB	DD	CC	AA	BB	CC	CC	CD

We find 3 times AB × AB and once BB × AB. Observation 10BB; expectation 10BB. Also 2AA × 2AB and AB × AA. Observation 12 AA; expectation 12AA.

---

[1]) The parents are not known. From the formulae of the brothers and sisters those of their parents have been deducted.

[2]) Taken from tab. h, cf. p. 87.

[3]) The parents are not known. From the formulae of the brothers and sisters those of their parents have been deducted.

[4]) For No. 1, see fam. 3c, tab. 33, p. 24, h, No. 2, fam. 3b, tab. 49, p. 25, k, No. 3 fam. 3n, tab. 11, p. 23, c, No. 4, fam. 3 m, tab. 64, p. 25, n, No. 5, fam. 3l, tab. 60, p. 25, m, No. 6, fam. 3a, tab. 12, p. 23, c, No. 7, fam. 3k, tab. 64, p. 25, n, No. 8, fam. 3, tab. 43, p. 25, j.

Fam. 3 tab. 43. Parents and seven children. Ind. 81.5 × 76.5 = = 77.3 + 79.2 + 83.7|+ 82.7 + 80.9 + 78.6 + 81.3.

Size − 0.1 × − 1.4 = −0.2 + −1.1 + −1.5 + −1.1 + −0.4 + + −0.7 + −0.6.

Size 12 × 9 = 12 + 10 + 9 + 10 + 11 + 11 + 11.

Size	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.								II	Ii	Ii	II	II	ii	ii	Ii	Ii	ii	ii	ii
F.								II	Ii	Ii	ii	ii	ii	ii	ii	ii	ii	ii	ii
1								II	II	II	Ii	Ii	ii	ii	Ii	Ii	ii	ii	ii
2								II	Ii	Ii	Ii	Ii	ii	ii	Ii	Ii	ii	ii	ii
3								II	ii	ii	Ii	Ii	ii	ii	ii	ii	ii	ii	ii
4								II	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii	ii	ii
5								II	Ii	Ii	Ii	Ii	ii	ii	Ii	Ii	ii	ii	ii
6								II	II	II	Ii	Ii	ii	ii	ii	ii	ii	ii	ii
7								II	Ii	Ii	Ii	Ii	ii	ii	Ii	Ii	ii	ii	ii

We find 2Ii × 2Ii, and 2Ii × 2ii. Obs. 4II; exp. 3.5II. Obs. 8ii; exp. 10.5ii.

Index. Form. 11A14I × 8A10I = 9A14I + 10A14I + 13A10I + +12A12I + 10A14I + 9A12I + 11A14I.

Form. 8A3C6B2D × 4A4C6B5D = 7A2C7B3D + 7A3C7B2D + + 8A5C2B4D + 8A4C4B3D + 7A3C7B2D + 5A4C7B3D + + 8A3C6B2D.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	AA	AA	AA	AA	AB	AB	AB	BB	BB	BB	BB	BB	DD	CC	AA	BB	CC	CC	CD
F.	AA	AA	BB	BB	AB	BB	BB	AB	BB	BB	DD	DD	CD	CC	CC	DD	CC	CC	CD
1	AA	AA	AB	AB	AB	BB	BB	BB	BB	BB	BB	BB	DD	AA	AA	DD	CC	CC	CD
2	AA	AA	AB	AB	BB	AB	AB	BB	BB	BB	BB	BB	CD	CC	AA	BB	CC	CC	DD
3	AA	AA	AB	AB	AB	AB	AB	AB	DD	DD	BB	BB	DD	CC	CC	DD	CC	CC	CC
4	AA	AA	AB	AB	AA	AB	AB	AB	BB	BB	BB	BB	CD	CC	CC	DD	CC	CC	DD
5	AA	AA	AB	AB	AB	BB	BB	AB	BB	BB	BB	BB	DD	CC	AA	BB	CC	CC	CD
6	AA	AA	AB	AB	AB	BB	BB	BB	BB	BB	BB	BB	CD	CC	CC	DD	CC	CC	CD
7	AA	AA	AB	AB	BB	AB	AB	AB	BB	BB	BB	BB	DD	CC	AA	BB	CC	CC	CD

That the indices of the children are higher than that of the father is a result of the crossing 2AA × 2BB. Further there are AB × AB, 2AB × 2BB, BB × AB and CD × CD. Obs. 11BB; exp. 12.25BB. Obs. 6 (CD and DD); exp. 5.25 (CD and DD). Total Obs. 17BB, CD and DD; exp. 17.5 BB, CD and DD.

Fam. 3a, tab. 12. Parents and three children. Ind. 83.6 × 80.2 = = 85.4 + 80.8|+ 85.9.

Size 0.5 × 0.9 = 1 + −0.3 + 0.2.

Size 13 × 14 = 14 + 11 + 12.

Size	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.									II	Ii	Ii	II	II	Ii	Ii	Ii	Ii	ii	ii
F.									II	II	II	II	II	Ii	Ii	Ii	Ii	ii	ii
1									II	II	II	II	II	Ii	Ii	Ii	Ii	ii	ii
2									II	Ii	Ii	II	II	ii	ii	ii	ii	ii	ii
3 [1])									II	Ii	Ii	II	II	Ii	Ii	ii	ii	ii	ii

We have 2Ii × 2II and twice 2Ii × 2Ii. Obs. 2II; exp. 6II. Obs. 6ii; exp. 6ii. So there is too small a number of II's. Here we must also accept non-hereditary variability. To this result may also cooperate that L + B incompletely indicates the headsize.

Index. Form. 12A16I × 10A16I = 14A16I + 11A12I + 14A14I.

Form. 10A2C6B1D × 8A2C8B1D = 12A2C4B1D + 7A4C5B3D + + 11A3C3B2D.

M.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	AA	AA	AB	AB	AA	AA	AB	AA	BB	BB	BB	BB	BB	AA	AA	BB	CC	CC	DD
F.	AA	AA	BB	BB	BB	BB	AB	AA	AA	AA	BB	BB	BB	AA	AA	BB	CC	CC	DD
1	AA	AA	AB	AB	AB	AB	AB	AA	AB	AB	BB	BB	BB	AA	AA	BB	CC	CC	DD
2	AA	AA	BB	BB	AB	AB	BB	AA	AB	AB	BB	BB	DD	CC	CC	DD	CC	CC	DD
3 [1])	AA	AA	AB	AB	AB	AB	AB	AA	AB	AB	BB	BB	BB	AA	CC	DD	CC	CC	DD

The high indices of the children are a result of the crossings 2AA × × 2BB and 2BB × 2AA. Further there are 2AB × 2BB and AB × × AB. Obs. 3BB; exp. 3.75BB.

Fam. 3b, tab. 49. Parents and seven children. Ind. 78.3 × 82.4 = = 83.4|+83 + 87.2 + 83.9 + 84.7 + 83 + 86.1.

Size 0.6 × −0.5 = −0.3 + 0.2 + −0.5 + 1.6 + 0 + 1 + 0.2.

Size 13 × 11 = 11 + 12 + 11 + 15 + 12 + 14 + 12.

Size	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	II	II	II	II	II	II	II	II	II	II	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii
F.	II	II	II	II	II	II	II	II	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii
1								II	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii
2								II	II	II	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii
3								II	Ii	Ii	Ii	Ii	ii	ii	Ii	Ii	ii	ii	ii
4								II	II	II	II	II	II	II	Ii	Ii	ii	ii	ii
5								II	Ii	Ii	ii	ii	Ii	Ii	Ii	Ii	ii	ii	ii
6								II	II	II	Ii	Ii	II	II	Ii	Ii	ii	ii	ii
7								II	II	II	II	II	ii	ii	ii	ii	ii	ii	ii

There are 2II × 2Ii, twice 2Ii × 2Ii and 2Ii × 2ii. Obs. 16II; exp. 14II. Obs. 12ii; exp. 14ii. There are somewhat too many II's.

Index. Formula. 9A16I × 12A14I = 13A14I + 12A14I + 14A14I + 12A16I + 13A14I + 12A16I + 14A12I.

Form. 7A2C9B1D × 9A3C5B2D = 10A3C4B2D + 9A3C5B2D +

[1]) Fam. 3r, tab. 25, p. 24.

+ 11A3C3B2D + 10A2C6B1D + 11A2C3B3D + 10A2C6B1D + + 10A4C2B3D.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	AA	BB	BB	BB	BB	AA	AA	AB	AB	AA	BB	BB	BB	BB	AA	BB	CC	CC	CD
F.	AA	AA	AA	AA	AB	AB	AB	AB	BB	BB	BB	BB	BB	AA	CC	DD	CC	CC	CD

1	AA	AB	AB	AB	BB	AA	AB	AB	AB	AB	BB	BB	BB	AB	CC	DD	CC	CC	DD
2	AA	AB	AB	AB	AB	AB	AB	BB	BB	AB	BB	BB	BB	AB	CC	DD	CC	CC	CD
3	AA	AB	AB	AB	AB	AA	AB	AB	AB	AB	BB	BB	DD	CD	AA	BB	CC	CC	CC
4	AA	AB	AB	AB	AB	AB	AA	BB	BB	AB	BB	BB	BB	AB	AA	BB	CC	CC	CD
5	AA	AB	AB	AB	BB	AA	AB	AB	AB	AB	DD	DD	BB	AB	AA	BB	CC	CC	CD
6	AA	AB	AB	AB	BB	AB	AA	AA	BB	AB	BB	BB	BB	AB	AA	BB	CC	CC	DD
7	AA	AB	AB	AB	AB	AA	AB	AA	AB	AB	BB	BB	DD	CD	CC	DD	CC	CC	CC

The high indices of the children result from the crossings 3BB × 3AA, BB × AA and AA × BB.

The crossing BB × AA yields twice CD. Further there are BB × AB AB × BB, AB × AB and CD × CD. Obs. 8BB; exp. 8.75BB. Obs. 2CC; exp. 1.75CC. Total: Obs. 13BB and (CD and DD); exp. 14BB and (CD and DD).

Fam. 3c, tab. 33. Parents and seven children. Ind. 80.2 × 84.5 = = 83.3 + 85.2 + 80 + 83.7|+ 86 + 83.5 + 86.7.

Size − 2.1 × −0.1 = 0.3 + −0.6 + − 1.3 + −0.6 + −0.2 + + 0.3 + − 0.2.

Size. 8 × 12 = 13 + 11 + 9 + 11 + 12 + 13 +12 .

Size.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	II	II	II	II	Ii	Ii	Ii	Ii	Ii	Ii	Ii		ii	ii	ii	ii	ii	ii	ii
F.	II	II	II	II	II	II	II	II	II	II	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii

1 [1])	II	II	II	II	II	II	II	II	II	II	II	II	Ii	Ii	ii	ii	ii	ii	ii
2					II	II	II	II	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii
3					Ii	Ii	Ii	Ii	II	II	Ii	Ii	ii	ii	ii	ii	ii	ii	ii
4					II	II	II	II	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii
5 [2])					II	II	II	II	II	II	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii
6 [3])					II	II	II	II	II	II	II	II	Ii	Ii	ii	ii	ii	ii	ii
7 [4])					II	II	II	II	II	II	II	II	ii	ii	ii	ii	ii	ii	ii

There are 4Ii × 4II, 2Ii × 2II, 2Ii × 2Ii and 2ii × 2Ii. Obs. 40II; exp. 24.5II. Obs. 4ii; exp. 10.5ii.

For the explanation of the headsizes as hereditary variations, while the heterozygotes are intermediate we want more II's than are available according the osbervations. (p. 000).

Index. Form. 10A12I × 13A14I = 13A14I + 14A14I + 10A12I + + 13A14I + 14A14I + 12A14I + 14A12I. Form. 7A3C5B4D ×

[1]) fam. 3 e, tab. 64, p. 25, n. [2]) fam. 3 d, tab. 34, p. 24, h.
[3]) fam. 3 f, tab. 11, p. 23, c. [4]) fam. 3 g, tab. 63, p. 25, n.

× 10A3C4B2D = 10A3C4B2D + 10A3C4B2D + 7A3C5B4D + + 10A3C4B2D + 9A4C5B1D (10A4C4B1D, p. 000) + 9A3C5B2D + + 10A4C2B3D.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	AA	AA	AA	AB	BB	AA	AB	BB	BB	AA	BB	BB	DD	DD	CC	DD	CC	CC	CD
F.	AA	AA	AA	AA	AA	AB	AB	AB	AB	BB	BB	BB	BB	AA	CC	DD	CC	CC	CD

1 [1])	AA	AA	AA	AB	AB	AA	BB	AB	AB	AB	BB	BB	BB	AB	CC	DD	CC	CC	CD
2	AA	AA	AA	AA	AB	AB	AB	AB	BB	AB	BB	BB	BB	AB	CC	DD	CC	CC	CD
3	AA	AA	AA	AB	AB	AA	BB	BB	BB	AB	BB	BB	DD	CD	CC	DD	CC	CC	CD
4	AA	AA	AA	AA	AB	AB	AB	AB	BB	AB	BB	BB	BB	AB	CC	DD	CC	CC	DD
5 [2])	AA	AA	AA	AB	AB	BB	AB	BB	AB	AB	BB	BB	BB	AB	CC	DD	CC	CC	C C
6 [3])	AA	AA	AA	AA	AB	AA	AA	BB	BB	AB	BB	BB	BB	AB	CC	DD	CC	CC	CD
7 [4])	AA	AA	AA	AB	AB	AB	AA	AB	AB	AB	BB	BB	DD	CD	CC	DD	CC	CC	C C

The high indices of the children result from the crossings BB × AA, AA × BB and DD × AA (yielding twice CD). Further there are AB × AB, twice BB × AB and CD × CD. Obs. 9BB; exp. 8.75BB. Obs. 2CC, exp. 1.75CC. Total: Obs. 14BB and (CD and DD); exp. 14BB and (CD and DD).

Fam. 3d, tab. 34. Two grandparents, parents and 14 children.
Ind. 86.3 × 82.6 = 78.7 + 81.2 + 85.8 + 79 + 85.2 + 77.9 + 79.5 + 79|+ 81.8 + 80.3 + 84.7 + 85.8 + 85 + 81.7.
Size −0.2 × −2.1 = 0.4 + −0.1 + −0.9 + −0.8 + −1.4 + − 0.7+ + −0.4 + 0.2 + −0.5 + −0.7 + −0.6 + −0.3 + 0 + −0.7.
Size 12 × 8 = 13 + 12 +10 +10 + 9 + 11 + 11 + 12 + 11 + 11 + 11 + 11 + 12 + 11.
Size Mother See fam. 3*c*, tab. 33, *d*, p. 34. Form 10II 4Ii 5ii.

Size.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	II	II	II	II	II	II	II	II	II	II	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii
F.	II	II	II	II	Ii	Ii	ii	ii	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii

1			II		II	II	Ii	Ii	II	II	II	II	II	II	ii	ii	ii	ii	ii
2					Ii	Ii	Ii	Ii	II	II	II	II	II	II	ii	ii	ii	ii	ii
3					II	II	Ii	Ii	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii
4					II	II	Ii	Ii	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii
5					II	II	Ii	Ii	II	II	ii	ii	ii	ii	ii	ii	ii	ii	ii
6					Ii	Ii	Ii	Ii	Ii	Ii	II	II	II	II	ii	ii	ii	ii	ii
7					II	II	Ii	Ii	II	II	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii
8					Ii	Ii	Ii	Ii	II	II	II	II	II	II	ii	ii	ii	ii	ii
9					II	II	Ii	Ii	II	II	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii
10					Ii	Ii	Ii	Ii	Ii	Ii	II	II	II	II	ii	ii	ii	ii	ii
11					II	II	Ii	Ii	II	II	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii
12					Ii	Ii	Ii	Ii	Ii	Ii	II	II	II	II	ii	ii	ii	ii	ii
13					II	II	Ii	Ii	Ii	Ii	II	II	II	II	ii	ii	ii	ii	ii
14					II	II	Ii	Ii	II	II	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii

[1]) fam. 3 e, tab. 64, p. 25, n. [2]) fam. 3 d, tab. 34, p. 24, h.
[3]) fam. 3 f, tab. 11, p. 23, c. [4]) fam. 3 g, tab. 63, p. 25, n.

We have twice 2 II × 2Ii and 4Ii × 4Ii. Obs. 62II; exp. 42 II. Obs. 4ii; exp. 14ii. There is too great a number of II's.

Index. Mother see fam. 3*c*, tab. 33, *d*, p. 000. Form. 3AA2ABBBAB BB2AB3BBABCCDD3CC.

Form. 14A14I × 12A12I = 9A14I + 11A14I + 14A14I + 10A14I + 14A10I + 9A14I + 10A14I + 10A14I + 11A14I + 10A14I + +13A14I + 14 A14I + 13A14I + 11A14I.

Form. 9A4C5B1D × 8A4C4B3D = 6A3C8B2D + 8A3C6B2D + + 11A3C3B2D + 7A3C7B2D + 9A5C1B4D + 6A3C8B2D + + 7A3C7B2D + 7A3C7B2D + 8A3C6B2D + 7A3C7B2D + 10 + 10A3C4B2D + 11A3C3B2D + 10A3C4B2D + 8A3C6B2D.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	AA	AA	AA	AB	AB	BB	A	B	BB	AB	AB	BB	BB	BB	A	B	CC	DD	CC	CC	C
F.	AA	AA	AA	AB	AB	AB	C	C	DD	BB	BB	AB	BB	BB	A	B	CC	DD	CC	CC	DD
1	AA	AA	AA	AB	AB	BB	A	B	BB	BB	BB	BB	BB	BB	B	B	CC	DD	CC	CC	CD
2	AA	AA	AA	BB	BB	AB	A	A	BB	AB	AB	AB	BB	BB	B	B	CC	DD	CC	CC	CD
3	AA	AA	AA	AA	AA	AB	A	B	BB	AB	AB	AB	BB	BB	A	B	CC	DD	CC	CC	CD
4	AA	AA	AA	AB	AB	BB	A	A	BB	BB	BB	BB	BB	BB	A	B	CC	DD	CC	CC	CD
5	AA	AA	AA	AB	AB	AB	C	C	BB	AB	AB	AB	DD	DD	C	C	CC	DD	CC	CC	CD
6	AA	AA	AA	AB	AB	BB	A	B	BB	BB	BB	BB	BB	BB	B	B	CC	DD	CC	CC	CD
7	AA	AA	AA	AA	AA	BB	A	A	BB	BB	BB	BB	BB	BB	A	B	CC	DD	CC	CC	CD
8	AA	AA	AA	BB	BB	AB	A	B	BB	BB	BB	AB	BB	BB	A	B	CC	DD	CC	CC	CD
9	AA	AA	AA	AB	AB	AB	A	A	BB	BB	BB	BB	BB	BB	A	A	CC	DD	CC	CC	CD
10	AA	AA	AA	AB	AB	BB	A	B	BB	BB	BB	BB	BB	BB	A	B	CC	DD	CC	CC	CD
11	AA	AA	AA	AA	AA	BB	A	A	BB	AB	AB	AB	BB	BB	A	B	CC	DD	CC	CC	CD
12	AA	AA	AA	AB	AB	AB	A	B	BB	AB	AB	AB	BB	BB	A	B	CC	DD	CC	CC	CD
13	AA	AA	AA	AB	AB	BB	A	A	BB	AB	AB	AB	BB	BB	A	B	CC	DD	CC	CC	CD
14	AA	AA	AA	BB	BB	AB	A	B	BB	AB	AB	BB	BB	BB	A	A	CC	DD	CC	CC	CD

We have twice BB × AB, 2AB × BB and AB × AB. Also once CC × DD. Obs. 37BB; exp. 38.5BB.

Fam. 3e, tab. 64. Four grandparents, parents and 10 children. A fine case of heredity of brachycephaly.

Index. 80.8 × 83.3 = 87.4 + 91.1 + 93 + 88.1 + 85.5|+ 82 + + 89.2 + 88.5 + 90.3 + 87.9.

Size −0.7 × 0.3 = − 0.1 + 0.3 + 1.2 + 0.8 + −0.3 + 0.5 + +0.6 + 1.2 + −1.1 + 1.2.

Size 11 × 13 = 12 + 13 + 14 + 14 + 11 + 13 + 13 + 14 + 10 + 14.

Mother. See fam. 3*b*, tab. 12, p. 42. Formula. Size. 10II2Ii7ii.

Father. See fam. 3c, tab. 33, p. 34. Formula. Size. 12II2Ii5ii.

	Children.																		
Size.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	II	II	II	II	II	II	Ii	Ii	Ii	Ii	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii
F.							II	II	II	II	II	II	Ii	Ii	ii	ii	ii	ii	ii
1							II	II	II	Ii	Ii	II	II	ii	ii	ii	ii	ii	ii
2							Ii	II	II	II	II	Ii	Ii	Ii	Ii	Ii			
3							II	Ii	Ii	II	II	II	II	II	Ii	Ii			
4							Ii	II	II	II	II	II	Ii	II	Ii	Ii			
5							II	Ii	Ii	Ii	Ii	II	II	ii	ii	ii			
6							II	II	II	II	II	II	Ii	Ii	ii	ii			
7							II	II	II	II	II	Ii	ii	Ii	Ii	Ii			
8							II	II	II	II	II	II	Ii	Ii	Ii	Ii			
9							Ii	Ii	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii			
10							II	II	II	II	II	II	Ii	Ii	Ii	Ii			

There are twice Ii × II, twice 2Ii × 2II, twice Ii × Ii and 2Ii × ii. Obs. 49II; exp. 35II. Obs. 8ii; exp. 15ii. So there is too great a number of II's. If for the headsize there is heredity while the heterozygotes are intermediate, a great non-hereditary variability (e.g. rachitis) must also be accepted here.

Index. Mother. See fam. 3*p*, tab. 12, p. 42. Form. 4BBAABBAA2 BBA B3AA3AB2CCCD.

The mother has a much lower index than the children. She has been measured twice; the index is 80.8 — 81 (dimensions L = 17.9 — 17.8, B 14.5 — 14.4). We have taken 81 as index, by which the formula became 11 A and not 10A.

Father, See fam. 3*c*, tab. 33, p. 34. Form. 3AA2ABAABB3AB3BB ABCCDD2CCCD.

Children. Ind. Formula. 10A16I × 13A14I = 15A13I + 18A16I + + 19A16I + 16A16I + 14A13I + 11A14I + 16A15I + 16A16I + + 17A14I + 15A16I.

Formula. 8A2C8B1D × 10A3C4B2D = 11A4C2B2D + 16A2C1D+ + 15A3CBB (16A3C, p. 000) + 14A2C2B1D + 9A4C3B2D (9A5C3B 1D) + 9A2C5B3D + 14A2C1B2D + 14A2C2B1D + 11A4C3B1D (12A4C2B1D) + 13A2C3B1D.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	BB	BB	BB	BB	AA	BB	AA	BB	BB	AB	AA	AA	AA	AB	AB	AB	CC	CC	CD
F.	AA	AA	AA	AB	AB	AA	BB	AB	AB	AB	BB	BB	BB	AB	CC	DD	CC	CC	CD
1	AB	AB	AB	BB	AA	AB	AB	AB	AB	BB	AB	AB	AB	CC	CC	CD	CC	CC	CD
2	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	CC	CC	CD
3	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AA	BB	CC	CC	CC
4	AB	AB	AB	BB	AB	AB	AB	AA	AA	AB	AB	AB	AB	BB	AB	AB	CC	CC	DD
5	AB	AB	AB	BB	AB	AB	AB	BB	BB	BB	AB	AB	AB	CC	CC	DD	CC	CC	CD
6	AB	AB	AB	BB	AA	AB	AB	BB	BB	BB	AB	AB	AB	BB	CD	DD	CC	CC	CD
7	AB	AB	AB	AB	AA	AB	AB	AB	AB	AA	AB	AB	CD	AB	AB	BB	CC	CC	DD
8	AB	AB	AB	AB	AB	AB	AB	BB	BB	AB	AB	AB	AB	AB	AA	AB	CC	CC	CD
9	AB	AB	AB	AB	AA	AB	AB	BB	BB	AA	AB	AB	AB	BB	CC	CD	CC	CC	CC
10	AB	AB	AB	BB	AA	AB	AB	BB	BB	AB	AB	AB	AB	AB	AB	AB	CC	CC	CD

The high indices of the children result from the crossings 3BB × 3AA BB × AA, 2AA × 2BB and twice AA × BB. Further there are BB × × AB, 2BB × 2AB, twice AB × AB, AB × DD and CD × CD. Obs. 25BB (and DD); exp. 25BB; Obs. 2CC; exp. 2.5CC.

Though the indices of the children are considerably higher than those of the parents, still the explanation is possible here by multiple factors with dominance (p. 6).

The mother has a relatively low index and descends from a greatly brachycephalic family. It is remarkable that the eldest daughter has the same index as the mother. The 1 st measurement gave as index 83.7, the 2nd measurement, 6 years later, 80.8; we took 82 for the mean index.

Fam. 3f, tab. 11. Three grandparents, parents and two children. Index. 83.5 × 82.2 =|87.5 × 91.

Size. 0.3 × 0.2 = 0.4 + 0.9, size. 13 × 12 = 13 + 14.

Mother. See fam. 3*c*, tab. 33, d_6, p. 34. Form. 12II2Ii5ii.

Father. Grandmother by father's side. Ind. = 84.5, size = 1.4, size = 15.

Size.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	II	II	II	II	II	II	II	II	II	II	II	II	Ii	Ii	ii	ii	ii	ii	ii
F.	II	II	II	II	II	II	II	II	II	II	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii

1	II	Ii Ii	II II	ii
2		II II	II II	

There are 2II × 2Ii and 2Ii × 2Ii. Obs. 6II; exp. 3II.

Index. Mother See fam. 3*c*, tab. 33, d_6, p. 34. Form. 4AAAB2AA 2BBAB3BBABCCDD2CCCD.

Ind. Form. 12A14I × 12A14I = 15A14I + 17A14I.

Form. 9A3C5B2D × 9A3C5B2D = 12A3C2B2D + 14A3C2D.

M.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	AA	AA	AA	AA	AB	AA	AA	BB	BB	AB	BB	BB	BB	AB	CC	DD	CC	CC	CD
F.	AA	AA	BB	BB	BB	BB	BB	AA	AA	AB	AA	AA	AA	AA	CC	DD	CC	CC	DD

1	AA	AA	AB	AB	BB	AB	AB	AB	AB	BB	AB	AB	AB	AB	CC	DD	CC	CC	CD
2	AA	AA	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	CC	DD	CC	CC	DD

The high indices of the children result from twice 2AA × 2BB, 2BB × 2AA and 3BB × 3AA. Further there are AB × BB and AB × AB. Obs. 2BB; exp. 1.5BB.

Fam. 3g, tab. 63. Four grandparents, parents and three children. Index. 86.7 × 80.6 = 90.5|+90.5 + 86.3.

Size. −0.2 × 0.8 = 0.8 + 0.7 + 1.2.

Size. 12 × 14 = 14 + 13 + 14.

Mother. See fam. 3*c*, d_7 tab. 33, p. 34; Formula Size 12II7ii.

Father. Index 77.3 × 77.8 = 80.6|. Size 0.3 × 1.3 = 0.8. Size 13 × 15 = 14.

Size.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.								II	II	II	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii
F.										II	II	II	Ii	Ii	Ii	Ii	Ii	Ii	ii
										II	II	II	Ii	Ii	Ii	Ii	ii	ii	ii

There are 2Ii × 2II, twice 2Ii × 2Ii and 2ii × 2Ii. Obs. 2II; exp. 3II. Obs. 2ii; exp. 3ii.

Size. Children.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.												II	ii	ii	ii	ii	ii	ii	ii
F.												II	Ii	Ii	Ii	Ii	ii	ii	ii
1												II	Ii	Ii	Ii	Ii	ii	ii	ii
2												II	Ii	Ii	ii	ii	ii	ii	ii
3												II	Ii	Ii	Ii	Ii	ii	ii	ii

There are twice 2ii × 2Ii. Obs. 2ii; exp. 6ii.

Index. Mother See fam. 3*c*, tab. 33, p. 34. Form. 3 AA3ABAA3AB 2BBDDCDCCDD3CC.

Father. Form. 8A16I × 9A18I = 11A16I. Form. 7A1C9B2D × + 9A9B1D = 9A2C7B1D.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	BB	BB	BB	BB	BB	BB	AA	AA	AA	AA	AA	AB	AB	BB	BB	BB	CD	CC	CD
F.	BB	BB	BB	BB	BB	AB	BB	AA	AA	AB	AB	AA	AA	AA	BB	BB	BB	AA	CD
1	BB	BB	BB	BB	BB	AB	AB	AA	AA	AA	AA	AA	AA	AB	BB	BB	CD	CC	CC

Index. Children. Formula. 14A12I × 11A16I = 17A16I + 17A14I + 14A16I.

Formula. 10A4C2B3D × 9A2C7B1D = 13A3C3B (14A3C2B) + + 14A3C2D + 12A2C4B1D.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	AA	AA	AA	AB	AB	AB	AA	AB	AB	AB	BB	BB	DD	CD	CC	DD	CC	CC	CC
F.	BB	BB	BB	BB	BB	AB	AB	AA	AA	AA	AA	AA	AA	AA	AB	BB	BB	CC	CD
1	AB	AB	AB	BB	BB	AA	AA	AA	AB	AB	AB	AB	AB	AB	AB	BB	CC	CC	CC
2	AB	AB	AB	AB	AB	AB	AB	AB	AA	AA	AB	AB	AB	AA	CD	DD	CC	CC	CC
3	AB	AB	AB	BB	BB	AA	AA	AA	AB	AB	AB	AB	AB	BB	AB	BB	CC	CC	CD

The high indices of the children result from 3AA × 3BB and 3BB × 3AA. Further there are 2AB × 2BB, 2AB × 2AB, AB × AB and CC × CD. Obs. 5BB and 1CD; exp. 6BB and 1.5CD.

Fam. 3h, see p. 30. Eight brothers and sisters. (the first generation).

Fam. 3k, tab. 64. One grandparent. parents and five children.

Index 82.5 × 81.2 = 81.7 + 83.3|+ 83.3 + 83.7 + 80.5.
Size − 1 × 0.4 = −0.5 + 0.7 + −0.5 + −0.9 + −0.1.
Size 10 × 13 = 11 + 13 + 11 + 10 + 12.

Father. G.f.f. Ind. 79.8. Size = 0. Size = 12.

Children. Size.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.								II	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii	ii	ii
F.								II	II	II	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii
1								II	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii
2									II	II	II	II	ii	ii	Ii	Ii			
3									Ii	Ii	Ii	Ii	Ii	Ii	ii	ii			
4									Ii	Ii	ii	ii	ii	ii	Ii	Ii			
5									II	II	Ii	Ii	Ii	Ii	ii	ii			

There are 2Ii × 2II, 2Ii × 2Ii and twice 2ii × 2Ii. Obs. 6II; exp. 7.5II. Obs. 12ii; exp. 12.5ii.

Index Form. 12A12I × 11A16I = 11A14I + 13A14I + 12A14I + 12A12I + 10A14I.

Form. 8A4C4B3D × 9A2C7B1D = 8A3C6B2D + 10A3C4B2D + + 9A3C5B2D + 9A2C3B5D (10A2C2B5D) + 8A2C6B3D.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	AA	AA	AA	AA	AA	AA	AB	AB	BB	BB	BB	BB	C C	DD	C C	DD	CC	CC	CD
F.	AB	AB	AB	AA	BB	AB	AB	AB	AB	BB	BB	BB	BB	AB	BB	BB	CC	CC	CD
1	AB	AA	AA	AA	AB	AB	BB	AA	AB	BB	BB	BB	AB	BB	CD	DD	CC	CC	CD
2	AA	AB	AB	AA	AB	AA	AA	AB	AB	BB	BB	BB	CD	DD	AB	BB	CC	CC	C C
3	AB	AA	AA	AA	AB	AB	AB	AB	BB	BB	BB	BB	AB	AB	CD	DD	CC	CC	DD
4	AA	AB	AB	AA	AB	AA	BB	AB	AB	BB	DD	DD	CD	CD	AB	BB	CC	CC	CD
5	AB	AA	AA	AA	AB	AB	AB	BB	BB	BB	BB	BB	AB	BB	CD	DD	CC	CC	CD

We have BB × AB, twice AB × AB, DD × AB and CD × CD. Obs. 8BB and 4 (CD and DD). Exp. 7.5 BB and 3.75 (CD and DD).

Fam. 3l, tab. 6o. Parents and two children.

Index 80.5 × 83.2 = 85.8|+ 84.5. Size 1.2 × −0.1 = 0.5 + 0.1. Size 14 × 12 = 13 + 12.

Size.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.								II	II	II	II	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii
F.								II	II	II	II	II	ii	.ii	ii	ii	ii	ii	ii
1								II	II	II	II	II	Ii	Ii	ii	ii	ii	ii	ii
2											II	Ii	Ii	ii	ii	ii	ii	ii	ii

There are Ii × II, twice Ii × ii and 3Ii × 3ii. Obs. II, exp. II. Obs. 3Ii; exp. 5Ii.

Index. Form. 10A17I × 12A12I = 14A14I + 13A13I.

Form. 10A7B2D × 8A4C4B3D = 11A3C3B2D + 11A2C2B4D.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	BB	BB	AA	AA	AB	BB	BB	AA	AA	AA	AA	BB	AB	BB	AA	BB	AA	CD	DD
F.	AA	AA	AB	AB	AB	AB	AA	BB	BB	AB	BB	BB	CC	DD	CC	DD	CC	CC	DD
1	AB	AB	AA	AA	AB	BB	AB	AB	AB	AB	AB	BB	AB	BB	CC	DD	CC	CC	DD
2	AB	AB	AB	AB	BB	AB	AB	AB	AB	AA	AB	BB	AA	DD	CC	DD	CC	CD	DD

There are AB × AB, BB × AB and CD × CC. The high indices of the children result from the crossings twice AA × BB, 2 BB × 2AA and BB × AA. Obs. 2BB and 1CD. Exp. 1.5BB and 1CD.

Fam. 3m, tab. 64. Parents and two children. Ind. 83.3 × 80.5 = 84.2|+ 83.7.

Size − 0.6 × 1.2 = − 0.5 + 0.1. Size 11 × 14 = 11 + 12.

Size	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.								II	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii
F.								II	II	II	II	II	Ii	Ii	Ii	Ii	ii	ii	ii
1								II	II	II	Ii	Ii	ii	ii	ii	ii	ii	ii	ii
2								II	Ii	Ii	II	II	Ii	Ii	ii	ii	ii	ii	ii

There are twice 2Ii × 2II, 2Ii × 2Ii and 2ii × 2Ii. Obs. 4II; exp. 5II. Obs. 6ii; exp. 3ii.

Index. Form. 12A 14I × 11A16I = 13A12I + 12A14I.

Form. 9A3C5B2D × 9A2C7B1D = 10A3C2B4D + 9A3C5B2D.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
F.	AB	AB	AA	AA	BB	AA	AA	AA	BB	AB	AB	BB	BB	BB	CC	DD	CC	CC	CD
M.	AA	AA	AB	AB	AB	BB	BB	AA	AB	BB	BB	BB	BB	AA	AA	BB	CC	CC	DD
1.	AB	AB	AA	AA	BB	AB	AB	AA	AB	AB	AB	BB	DD	CD	CC	DD	CC	CC	CD
2.	AA	AA	AB	AB	AB	AB	AB	AA	BB	BB	BB	BB	BB	AB	CC	DD	CC	CC	DD

There are twice BB × AB and 2AB × 2BB. Obs. 4BB; exp. 4BB.

Fam. 3n, tab. 11. Parents and six children.

Index 82.2 × 80.9 = 81.1 + 85.7|+ 84.3 + 82.5 + 83.1 + 83.2.

Size 1.2 × 0.4 = 1.1 + 0.8 + 0.4 + 0 + 0.4 + 0.1.

Size 14 × 13 = 14 + 14 + 13 + 12 + 13 + 12.

Size.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.								II	Ii	Ii	II	II	II	II	Ii	Ii	ii	ii	ii
F.								II	II	II	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii
1								II	II	II	II	II	Ii	Ii	Ii	Ii	ii		
3									Ii	Ii	II	II	II	II	Ii	Ii			
2									II	II	Ii	Ii	Ii	Ii	Ii	Ii			
4									Ii	Ii	Ii	Ii	II	II	ii	ii			
5									II	II	II	II	Ii	Ii	ii	ii			
6									Ii	Ii	Ii	Ii	Ii	Ii	Ii	Ii			

There are 2Ii × 2II, twice 2II × 2Ii and 2Ii × 2Ii. Obs. 16II; exp. 21II. Obs. 4ii; exp. 3ii.

Index. Form. 11A16I × 11A16I = 11A16 + 14A16I + 13A16I + + 12A14I + 12A14I + 12A16I. Form. 9A2C7B1D × 9A2C7B1D = = 9A2C7B1D + 12A2C4B1D + 11A2C5B1D + 10A2C4B3D + 10A2C4B3D + 10A2C6B1D.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	AA	AA	AB	BB	AB	AB	AA	AA	AB	AA	BB	BB	BB	BB	BB	BB	CC	CC	CD
F.	AA	AA	AB	AB	AA	BB	BB	AB	AB	BB	BB	BB	BB	AA	AA	BB	CC	CC	DD

1	AA	AA	AB	BB	AA	BB	AB	AB	BB	AB	BB	BB	BB	AB	AB	BB	CC	CC	DD
2	AA	AA	AA	AB	AB	AB	AB	AB	AB	AB	BB	BB	BB	AB	AB	BB	CC	CC	CD
3	AA	AA	AB	BB	AA	AB	AB	AA	AA	AB	BB	BB	BB	AB	AB	BB	CC	CC	CD
4	AA	AA	AA	BB	AB	AB	AB	AA	AB	AB	BB	BB	BB	AB	CD	DD	CC	CC	DD
5	AA	AA	AB	AB	AA	BB	AB	AA	AA	AB	BB	BB	BB	AB	CD	DD	CC	CC	CD
6	AA	AA	BB	AB	AB	BB	AB	AB	AB	AB	BB	BB	BB	AB	AB	BB	CC	CC	DD

The high indices of the children result from the crossings twice AA × BB and twice BB × AA (yielding twice CD). We have twice AB × AB, BB × AB and AB × BB. Obs. 8BB; exp. 9BB.

Fam. 30, tab. B [1]). Mother, son and two daughters. The father is deceased; father belonged to the brothers and sisters of fam. h (p. 30). The mother is dolichocephalic, the two daughters have also dolichocephalic indices.

Ind. 79.3 × x = 81.7|+79.7 + 78.7. Size 1.2 × x = 1.2 + −0.5 + 0.3.

Fam. 3p, tab. 12. Parents and three children. See also fam. 3e, tab. 64, p. 36.

Index 84.5 × 82.5 = 87.5|+ 80.8 + 83.4.

Size. 0.3 × 1 = 0.5 + −0.7 + 0.3. Size 13 × 14 = 13 + 11 + 13.

Size.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	II	II	II	II	II	II	Ii	Ii	Ii	II	Ii	Ii	II	Ii	II	II	ii	ii	ii
F.	II	II	II	II	II	II	II	II	II	Ii	II	II	Ii	Ii	Ii	Ii	Ii	ii	ii

1						II	II	Ii	Ii	II	II	II	Ii	Ii	Ii	Ii	ii	ii	ii
2							Ii	Ii	Ii	Ii	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii
3							II	II	II	Ii	Ii	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii

There are 2Ii × 2II, II × Ii, twice Ii × Ii, 2 Ii × 2Ii and ii × Ii Obs. 3II; exp. 7.5II. Obs. 7ii; exp. 4.5ii.

Index. Form. 13A16I × 12A17I = 15A16I + 11A 16I + 12A17I.

Form. 11A2C5B1D × 11A1C6B1D = 13A2C3B1D + 9A2C7B1D + + 11A1C6B1D.

[1]) not published.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	AB	BB	BB	BB	AA	AB	AB	AB	AB	AB	AA	AB	AA	AB	BB	BB	C C	CC	CD
F.	BB	AB	AB	AB	AA	BB	AA	BB	BB	BB	AB	AA	AB	BB	AA	AB	AA	CC	DD
1	AB	AB	AB	AB	AA	AB	AB	AB	AB	BB	AB	AB	AB	BB	AB	BB	C C	CC	DD
2	BB	BB	BB	BB	AA	BB	AA	BB	BB	AB	AA	AA	AA	AB	AB	AB	C C	CC	CD
3	BB	AB	AB	BB	AA	BB	AB	AB	AB	BB	AB	AB	AB	BB	AB	BB	AA	CC	DD

There are four times AB × BB, 2AB × 2BB, 2BB × 2AB and twice BB × AB. Obs. 16BB; exp. 15BB.

Fam. 3r, tab. 25. Four grandparents, parents and two children. Mother. See fam. 3*a* tab. 12. Size, formula. 8II2Ii2II2Ii5ii.

Index form. 2AA2AB2AAABAA5BB2AABB2CCDD.

Father. Index 78.3 × 78.8 = 78.5. Size — 0.3 × —o.2 = —0.9. Size. 11 × 12 = 10.

Size.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.								II	Ii	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii	ii
F.								II	II	II	Ii	Ii	ii	ii	Ii	Ii	ii	ii	ii
1								II	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii	ii	ii

There are 2Ii × 2II, 2Ii × 2Ii, 2Ii × 2ii and 2ii × 2Ii. Obs. 0II; exp. 1II, Obs. 4ii; exp. 2.5ii.

Index. Form. 9A14I × 10A14I = 9A12I. Form. 9A1C5B4D (8A1C6B4D) × 10A1C4B4D (9A1C5B4D) = 9A1C3B6D (8A1C4B6D

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	AA	AA	BB	BB	AB	AB	AA	AA	AA	AB	BB	BB	BB	AA	DD	C C	DD	CD	DD
F.	AA	AA	AB	AB	AA	AA	AB	AB	AA	BB	AB	BB	DD	C C	BB	BB	DD	DD	DD
1	AA	AA	AB	AB	AA	AA	AA	AA	AA	BB	BB	BB	DD	C C	DD	CD	DD	DD	DD

There are 2BB × 2AB, AB × BB and BB × AB. Obs. 2BB; exp. 2BB.

Children. Index. 85.9 × 78.5 = 78.+ 78.5|. Size. 0.2 × —0.9 = =0. + —0.3. Size 12 × 10 = 12 + 11.

Size.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.								II	Ii	Ii	II	II	Ii	Ii	ii	ii	ii	ii	ii
F.								II	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii	ii	ii
1								II	Ii	Ii	II	II	Ii	Ii	ii	ii	ii	ii	ii
2								II	Ii	Ii	Ii	Ii	Ii	Ii	ii	ii	ii	ii	ii

There are 2Ii × 2Ii, 2II × 2Ii and 2Ii × 2ii. Obs. 2II; exp. 3II. Obs. 0ii; exp. 3ii.

Index Form. 14A14I × 9A12I = 9A14I + 9A14I. Form. 11A3C3B2D × 6A3C6B4D = 10A4B5D (9A5B5D) + 10A4B5D (9A5B5D).

M.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	AA	AA	AB	AB	AB	AB	AB	AA	AB	BB	BB	BB	BB	AA	CC	DD	CC	CC	DD
F.	AA	AA	AB	AB	AA	AA	AA	AA	AA	BB	BB	BB	DD	CC	DD	CD	DD	DD	DD
1.	AA	AA	AB	AB	AA	AA	AA	AA	BB	AB	BB	BB	BB	AA	CD	DD	CD	CD	DD
2.	AA	AA	AA	BB	AB	AB	AB	AA	AB	AB	BB	BB	BB	AA	CD	CD	CD	CD	DD

The low indices of the children result from the crossings 3 times CC × DD = CD. Also from twice 2AB × 2AB. Further there is AB × BB. Obs. 2BB; exp. 2BB.

While fam. 3 is greatly brachycephalic with many examples of dominance of macrobrachycephaly, we have here in fam. 3*r* an example of recessiveness of microbrachycephaly. The explanation is easily possible by the assumption of a crossing CC × DD and 2CC × 2DD. This fam. 3*r* with four grandparents shows us very well the significance of the factors we have accepted for heredity.

As we have accepted that the effect of the factors C and D is larger than that of the factors A and B, we had to accept one factor A more, as there were here 5 factors D and no factor C, or also 6 factors D and one factor C present (cf. p. 14, note).

According to the 2nd scheme there would in principle the same explanation to be attained.

The drawing up of the formulae for the headsize of the different families of tab. 3 often led to difficulties. In some cases there were more, in other cases fewer II's than was expected. There is still to be examined whether in the heredity of the headsize with man the heterozygotes are intermediate, or whether there occur any factors with dominance. A. SCHREINER (1923) finds indications for the latter (p. 11, 12) [1]).

Of the different families of tab. 3, for which we have drawn up the formulae of the indices, are many brachycephalic. Fam. 3e, and 3g with the greatly brachycephalic indices of the children may remind of prepotency. It appears from the formulae that they may also be explained very well by the hypothesis of polymere factors with dominance of macrobrachycephaly (p. 6). And we rather feel for this explanation when we take into consideration the fam. 3d with the divergent indices of the children. It also greatly proves for mendelian heredity that in fam. 3*r*, where the mother has a high index and belongs to the brachy-

[1]) I remember that in our material for young children L + B is not exact (p. 3, note).

cephalic fam. 3, the two children are dolichocephalic, just like the father and the grandparents by father's side. Here the significance of the assumption of dominance of microdolichocephaly shows clearly.

Interesting remarks on very high indices are made by E. FISCHER (1923, S. 1476) and by A. SCHREINER (1923). FISCHER finds with avitaminose experiments in rats, that the animals are small and are more brachycephalic than control animals. (see also p. 1, note).

The 2nd scheme would have led us to corresponding formulae. The maintenance of this scheme is however different. For the explanation of some families crossings AA × aa (macrobrachy- × microdolichocephalic) will be necessary. For fam. 3*r* crossings BB × bb (macrodolicho- × microbrachycephalic) ought to be accepted. The formulae of the indices must be drawn up in normalised heads (p. 18).

In applying the 1st scheme to the many families of our material only in a few cases difficulties were met with. Difficult and interesting families, that all found their consideration with the inquiry of the different matings, are in the tables 1—35, fam. 245a tab. 2, fam. 68 tab. 3, fam. 32f tab. 4, fam. 377 tab. 9, fam. 216j tab. 9, fam. 160 tab. 10, fam. 177dd tab. 13, fam. 82 tab. 13, fam. 90 tab. 14, fam. 34 tab. 15, fam. 57 tab. 19, fam. 269a tab. 20, fam. 3r tab. 25, fam. 271c tab. 28, fam. 73a tab. 35. And in the tables 36—74, fam. 324b tab. 43, fam. 130 tab. 48, fam. 179d tab. 50, fam. 10b tab. 52, fam. 216e tab. 53, fam. 15a tab. 61, fam. 66 tab. 61, fam. 209 tab. 62, fam. 82b tab. 62, fam. 364 tab. 65, fam. 87c tab. 66, fam. 380j tab. 73.

I abstain from publishing these families. In all cases it was possible to draw up the formulae. As an example I give the formulae of fam. 245

Fam. 245a. Four grandparents, parents and seven children.

This family 245a has been discribed in the general treatment of the heredity of the headform of the second study on the material (1921 c, p. 24) as an example of prepotency. We now shall see that by the adoption of multiple factors with dominance, as has been done in this third treatment of the material, the mendelian explanation is very well possible.

Mother. Fam. 245, tab. 8. Parents and three children. The mother of fam. 245a is the third daughter here. Ind. 77 × 80.5 = 79.3 + 81.1 + + 85.8. Size 0.8 × 0.6 = 1 + 1.1 + 0.9; size 14 × 13 = 14 + 14 + + 14.

Size.	1 2 3 4 5 6 7 8 9 10 11 12	13 14	15 16	17 18 19
M.		II	Ii Ii	Ii Ii	ii ii ii
F.		II	Ii Ii	ii ii	ii ii ii
1			Ii Ii	Ii Ii	
2			II II	ii ii	
3			Ii Ii	Ii Ii	

We find 2Ii × 2Ii and 2Ii × 2ii. Obs. 2ii. Exp. 4.5ii.

Index. Form. 8A16I × 11A14I = 9A16I + 11A14I + 14A16I.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	AA	AA	AA	AA	AB	AB	AB	BB	BB	BB	BB	BB	BB	BB	BB	BB	CC	DD	CD
F.	BB	BB	BB	AA	AB	AB	AB	AA	AB	BB	AB	AA	AB	BB	DD	CC	CC	DD	CD
1	AB	AB	AB	AA	BB	BB	BB	AB	AB	BB	BB	AB	BB	BB	BB	AB	CC	DD	CD
2	AB	AB	AB	AA	AA	AB	AB	AB	BB	BB	AB	AB	AB	BB	DD	CD	CC	DD	CD
3	AB	AB	AB	AA	AB	AA	AA	AB	BB	BB	AB	AB	AB	BB	BB	AB	CC	DD	CC

The high and divergent indices of the children result from the crossings 3AA × 3BB, BB × AA, 2AB × 2AB, AB × AB and CD × CD. Obs. 7BB and 2CD; exp. 6.75BB and 2.25 (CD and DD). The formula of the 2nd child 11A14I = 10A1C4B4D is reduced to 11A1C3B4D (p. 14).

Father. Ind. 79.7 × 84.3 = 78.2|. Size —0.4 × 1.9 = 0.8; size 11 × 16 = 14.

Size.	1 2 3 4 5 6 7 8	9	10 11 12 13 14 15 16	17 18 19
M.		II	Ii Ii Ii Ii ii ii ii	ii ii ii
F.		II	II II II II II II II	ii ii ii
1		II	II II II II Ii Ii Ii	Ii ii ii

The father of fam. 245*a* is the son here.

Ind. Form. 10A13I × 13A16I = 9A16I.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	AA	AA	AA	AB	AB	BB	BB	BB	AA	AB	BB	BB	AA	DD	DD	DD	CC	DD	CC
F.	AA	AA	AB	AB	BB	AB	AB	AB	AA	AA	BB	BB	AB	BB	BB	AB	CC	DD	CC
1	AA	AA	AB	BB	BB	BB	BB	BB	AA	AA	BB	BB	AB	BB	BB	AB	CC	DD	CC

We have three times AB × AB, 3BB × 3AB. Obs. 4BB; exp. 2.25BB.

Children. Ind. 85.8 × 78.2 = 82 + 85| + 85 + 81.5 + 82.3 + 86 + 85.3.

Size 0.9 × 0.8 = 1.8 + 0.5 + 0 + 0.5 + 0.7 + —0.2 + 0.4.

Size 14 × 14 = 16 + 13 + 12 + 13 + 13 + 12 + 13.

Size.	1 2 3 4 5 6 7 8 9	10 11 12	13 14	15 16	17 18 19
M.		II II II	Ii Ii	Ii Ii	ii ii ii
F.		II II II	Ii Ii	Ii Ii	ii ii ii
1		II	II II	II II	ii ii ii
2		II	Ii Ii	ii ii	
3		II	ii ii	ii ii	
4		II	ii ii	Ii Ii	
5		II	Ii Ii	ii ii	
6		II	ii ii	ii ii	
7		II	ii ii	Ii Ii	

We have twice 2Ii × 2Ii. Obs. 4II; exp. 7II. Obs. 16ii; exp. 7ii.

Index. Form. 14A16I × 9A16I = 12A16I + 14A14I + 13A12I + + 11A14I + 11A14I + 14A12I + 13A14I.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
M.	AB	AB	AB	AA	AB	AA	AA	AB	BB	BB	AB	AB	AB	BB	BB	AB	CC	DD	CC
F.	AA	AA	AB	BB	BB	BB	BB	BB	AA	AA	BB	BB	AB	BB	BB	AB	CC	DD	CC
1	AB	AB	AB	AB	BB	AB	AB	BB	AB	AB	AB	AB	BB	BB	BB	BB	CC	DD	CC
2	AA	AA	AA	AB	AB	AB	AB	BB	AB	AB	AB	AB	AB	BB	DD	CD	CC	DD	CC
3	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	BB	BB	CD	DD	DD	CC	CC	DD	CC
4	AB	AB	BB	AB	BB	AB	AB	AB	AB	AB	BB	BB	CD	DD	BB	AB	CC	DD	CC
5	AA	AA	AB	AB	BB	AB	AB	BB	AB	AB	BB	BB	AB	BB	DD	CD	CC	DD	CC
6	AB	AB	BB	AB	AB	AB	AB	AB	AB	AB	AB	AB	CC	DD	DD	CD	CC	DD	CC
7	AA	AA	AB	AB	AB	AB	AB	BB	AB	AB	AB	AB	DD	DD	BB	BB	CC	DD	CC

We have three times AB × AB, twice AB × BB and 2AB × 2BB. Further AA × BB, 2AA × 2BB and 2BB × 2AA. Obs. 19BB; exp. 19.25BB. The high indices of the children ensue from the crossings AA × BB = AB, 2AA × 2BB = 2AB and 2BB × 2AA = 2AB. Though one of the parents of the mother has a dolichocephalic index (fam. 245), the mother has three times the term AA, that meet with terms BB of the father.

In some of the above mentioned cases, both parents have low indices and all children high indices. Here the assumption in the mating of crossings AA × BB and BB × AA gives the result desired. Conversely if both parents have high indices and all children low indices, we try to accept in the mating the crossings CC × DD = CD and DD × CC = = CD. These cases occur rarely and as the number of C and D factors is generally small, and divergent in the children, only some of these crossings may be accepted. In these cases may also the crossings AB × AB be considered (fam. 34, tab. 15).

When one of the parents has a high and the other a low index and all children high indices, we accept many crossings AA × BB = AB. When in similar cases all children have low indices, we accept crossings CC × DD = CD (fam. 269*a*). Also here we are generally not free in accepting the number of C and D factors. Then we accept also crossings AB × AB.

The application of the first scheme suffers by it, as has been said, that we have taken for the headsize the value of L + B. If we knew the headsize better, we could draw up the formulae still more accurately.

The application of the 2nd scheme agrees with the first as we have seen (p. 20). It must be reserved to later material.

CHAPTER IV

INDEX AND SEX

The significance of the sex for the heredity of the headindex may appear in different ways. We know:

1. Secondary characters of sex.
2. Sex-linked inheritance.
3. Different dominance in male and in female.
4. The agreement of the sons with the father and of the daughters with the mother. Patrocliny and matrocliny.

1. That we find the index of females higher than those of males may be a secondary character of sex. So there is a female influence then, which in all cases makes the indices of females greater than those of males.

We have found that there is another correlation between length and breadth in female than in male (1922 p. 522) and take this difference as secondary character of sex. (GEROULD 1923, p. 497, 498).

2—4. The other possible influences of sex on the headindex.

There appeared from the classification, according to tab. *f* and *g* (p. 26, 27), that of the families, where L + B is small the number of dolichocephalic indices was among the fathers considerably larger than the number of brachycephalic indices. Among the mothers there is hardly any difference between the number of dolichocephalic indices in heads, where L + B is large and where L + B is small.

If in a population there appear more microdolichocephalic indices than microbrachycephalic indices, this may be a result from dominance of microdolichocephaly to microbrachycephaly.

The number of families that, according to the classification, each group contains, we may confront in pairs in the following way:

I 1*a* : I 1*b*, mabr × mado : mado × mabr, = 45 : 31
I 2*c* : I 2*d*, mabr × mabr : mado × mado, = 47 : 28

II 3*e* : II 3*f*, mido × mibr : mibr × mido, = 12 : 27
II 4*g* : II 4*h*, mido × mido : mibr × mibr, = 20 : 23
III 5*i* : III 5*j*, mabr × mido : mido × mabr, = 32 : 20
III 5*k* : III 5*l*, mado × mibr : mibr × mado, = 7 : 32
III 6*m* : III 6*n*, mabr × mibr : mibr × mabr, = 23 : 23
III 6*o* : III 6*p* mado × mido : mido × mado, = 19 : 16

The number of families of group I 1*a* is greater than of group I 1*b*, because the mean index of female is higher than that of male. For the same reason the number of families of group I 2*c* is greater than that of group I 2*d*.

The number of families of group II 3*f* mibr × mido is greater than that of group II 3*e* mido × mibr, because microdolichocephaly is dominant to microbrachycephaly and because we find in our material this dominance more strongly expressed in the fathers than in the mothers.

The number of families of group II 4*g*, mido × mido differs little from group II 4*h* mibr × mibr, because the mean index of female is indeed greater than that of male, but also because microbrachycephaly especially of the father is recessive as opposed to microdolichocephaly. Both influences thwart each other.

The number of families of group III 5i, mabr × mido is greater than that of group III 5*j* mido × mabr, because the mean index of female is greater than that of male. Further is in the first case the father microdolichocephalic and in the second macrobrachycephalic; both are characters with dominance and so influence the number of families in the same way.

The number of families of group III 5*k* mado × mibr is so much smaller than of group III 5*l* mibr × mado, because the mean index of female is greater than that of male and moreover because microbrachycephaly is recessive in the father.

The number of families of the groups III 6*m* and *n* mabr × mibr and mibr × mabr and of III 6*o* and *p* mado × mido and mido × mado do not differ much.

The significance for our material of the recessiveness of the microbrachycephalic index, which for the whole material manifests itself in the tab. *f* and *g*, we find back in the different groups.

If macrobrachycephaly is dominant to macrodolichocephaly and microdolichocephaly to microbrachycephaly, there will appear in the

matings where both parents have large heads, more macrobrachycephalic than macrodolichocephalic indices among the children and in the matings where both parents have small heads, more microdolichocephalic than microbrachycephalic indices.

From our protocols we have drawn up the following lists:

Tab. *i*.

Tables All children	Sons		Daughters	
	mabr.	mado.	mabr.	mado.
1—19	117	90	160	85
in %	56.5	43.5	65.3	34.7

Tables All children	Sons		Daughters	
	mibr.	mido.	mibr.	mido.
20—35	63	60	94	53
in %	51.2	48.8	64	36

We see from these lists that of the families where both parents have large heads, the percentage of macrobrachycephalic indices both for the sons and the daughters is greater than the percentage of macrodolichocephalic indices. For the families where both parents have small heads, the percentage of microbrachycephalic indices for the sons is smaller than the percentage of macrobrachycephalic indices in the preceding table.

As in our opinion, there exists in the microbrachycephalic indices a great non-hereditary variability which has great influence especially in young children, we have drawn up also similar lists for the adult children. So we find:

Tab. *k*.

Tables adult children	Sons		Daughters	
	mabr.	mado.	mabr.	mado.
1—19	50	38	67	32
in %	56.8	43.2	67.7	32.3

Tables adult children	Sons		Daughters	
	mibr.	mido.	mibr.	mido.
20—35	16	29	30	26
in %	32.6	67.4	53.6	46.4

In these tables of small numbers we find both, for the sons and the daughters of parents with small heads, a considerably smaller number of microbrachycephalic indices than of parents with large heads macrobrachycephalic indices. This difference is for the sons much greater than for the daughters. So here the recessiveness of the microbrachycephalic index seems to manifest itself.

We have also determined the mean index of the sons and of the daughters of parents with large heads (tab. 1—19) and of parents with

small heads (tab. 20—35). From tab. *l* we see that the mean index of the sons of parents with small heads is smaller than of parents with large heads. So this difference may also rest on the dominance of microdolichocephaly over microbrachycephaly. For the daughters we find

Tab. *l*.

Tables	L + B of both parents	Sons			Daughters		
		N.	mean ind.	stand. dev.	N.	mean ind.	stand. dev.
1—19	large	272	80.42	3.12	345	80.68	2.95
20—35	small	161	80.06	3.32	195	80.93	2.94

the mean index in families where the parents have large heads to be greater than in families where they have small heads. It is possible that here the result has been altered by non-hereditary variations.

According to the second scheme (p. 15) a factor A for brachycephaly, which makes the head especially broader, is dominant to a factor a for dolichocephaly, which makes the head especially narrower. Dolichocephalic indices belonging to large heads of which, after being normalized (p. 18), L + B is small, will therefore contain many a factors. This is according to the 2nd scheme the recessive form of dolichocephaly. The fact that, in our material, of the fathers of whom L + B is small, the number of dolichocephalic indices is greater than the number of brachycephalic indices (tab. *f* and tab. *g*, p. 26, 27), is therefore without further assumptions not to be explained according to the second scheme. Also here we should perhaps have to accept an influence of the sex.

We will now examine whether the differences in the numbers of brachy- and dolichocephalic indices in males and females that we find, may be explained by the influence of sex we mentioned sub. 2—4. (p. 48).

2. Sex linked inheritance.

If there is sex linked inheritance for the headindex, we have for the pair of factors A and B, of which A, being a factor for brachycephaly in large heads, is dominant to B, being a factor for dolichocephalic in large heads, the following crossings.

Suppose x = macrobrachycephaly and x = macrodolichocephaly, while the male is heterozygous.

N.	Crossings	Results of crossings	Explication	brachyc.		dolichoc.	
				D.	S.	D.	S.
1	mabr. × mabr.	$xx \times xo = xx + xo$	all children mabr.	2	2		
2	„	$xx \times xo = xx + xx + xo + xo$	daughters mabr, half the number of sons mabr, the other half mado	2	1		1
3	mabr. × mado.	$xx \times xo = xx + xo$	all children mabr.	2	2		
4	„	$xx \times xo = xx + xx + xo + xo$	daughters and sons, half of each number of sons and daughters mabr and mado	1	1	1	1
5	mado. × mabr.	$xx \times xo = xx + xo$	daughters mabr. and sons mado	2			2
6	mado. × mado.	$xx \times xo = xx + xo$	all children mado			2	2
			Total	9	6	3	6

In the matings macrobrachycephalic × macrobrachycephalic we shall meet among the sons more macrodolichocephalic indices than among the daughters, and they will occur more frequently than the matings mado × mado.

The matings macrobrachy- × macrodolichocephaly will occur more frequently than the reciprocal matings macrodolicho- × macrobrachycephaly. In the former matings we shall find more macrodolichocephalic indices than in the latter. The crossing mado × mabr does not give at all macrodolichocephalic indices for the daughters.

The crossing mado × mabr gives no cases where all indices are macrobrachycephalic. This we have also found more or less. This crossing however gives macrobrachycephalic indices for the daughters and macrodolichocephalic indices for the sons. This we have not found.

These crossings give for every 16 daughters a total of 9 with brachycephalic and 3 with dolichocephalic indices; for the sons the numbers of brachycephalic and dolichocephalic indices are equal.

According to our first scheme brachycephaly is recessive in small heads. So, now that we suppose that there is sex-linkedness, C will be recessively and D dominantly sex-linked. Then among the daughters more microdolichocephalic indices are met with than among the sons, and among the sons more microbrachycephalic indices than among the daughters. There will also be more crossings mido × mibr than mibr. × mido. This however we do not find in our material. While, as a

general result, there was still some reason to accept that macrobrachycephaly was sex-linked and dominant, yet we drop the idea of sex-linkedness for the heredity of the index, now that the conception that microbrachycephaly is sex-linked and recessive, does not go at all with our results.

Also the second scheme of factors of heredity (A and a, B and b, C and c), does not offer a better possibility to explain the differences found in the sons and the daughters by sex-linked inheritance. If we accept that f.i. from the factors B and b, b for the (normalized) short head (p. 15) is recessive in respect of the factor B for the (normalized) long head, we shall also find here, that these short heads occur more frequently in females than in males, and also that the narrow heads (aa) occur more frequently in males than in females. And as the male is heterozygous for the sex, we shall experience in applying sex-linkedness for the explanation of the various dominance according to the 2nd scheme, the same difficulties as we met with in working it out according to the first scheme.

There is no ordinary coupling because there are not in both sexes in the same degree more brachycephalic than dolichocephalic indices.

So we reject sex-linked inheritance for the explanation of the heredity of the headindex and now pass to examining:

3. various dominance for both sexes.

When macrobrachycephaly is dominant in female and recessive in male, on the other hand macrodolichocephaly dominant in male and recessive in female, the crossing mabr × mado may then be:

Tab. *m*.

♀ ♂	♀		♂	
	Brachy	Dolicho	Brachy	Dolicho
AA × BB =	4AB		+	4AB
AB × BB =	2AB	+ 2BB	+	2AB+2BB
AA × AB =	2AA + 2AB		+ 2AA	+ 2AB
AB × AB =	AA + 2AB	+ BB	+ AA	+ 2AB+BB
total mabr. × mado.	13 brachy	+ 3 dolicho	+ 3 brachy	+ 13 dolicho

and the crossing mado × mabr may be:

BB × AA = AB + AB = 16 brachyc. (daughters) + 16 dolichoc. (sons).

Thus we see that the crossing macrobrachy- × macrodolichocephalic contains among the daughters fewer brachycephalic indices and more dolichocephalic indices, and among the sons more brachycephalic and fewer dolichocephalic indices than the crossing macrodolicho- × macrobrachycephalic. In both crosses the daughters contain much more brachycephalic than dolichocephalic indices and the sons much more dolicho- than brachycephalic indices.

When microdolichocephaly is dominant in male and recessive in female, and microbrachycephaly is dominant in female and recessive in male, for the crossings mido × mibr and the reciprocal crossing mibr × mido, the same is of value as what above has been said for the crossings mabr × mado and mado × mabr.

In our material we have found that there are more macrobrachycephalic indices among the daughters (p. 87) than among the sons, there are also more and more distinct matings mabr × mado = mabr than mado × mabr = mabr.

In the tab. 1 and 2 mabr × mado = mabr and = mabr + mibr, and in the tab. 6 and 7 mado × mabr = mabr and = mabr + mibr, we find more daughters than sons (p. 59).

We therefore accept that macrobrachycephaly is dominant to macrodolichocephaly, but more strongly in the daughters than in the sons.

We also find more microdolichocephalic indices among the males than among the females, both among the fathers and mothers (tab. f, g), and among the sons and daughters (tab. n—q). There are also more and more distinct matings microbrachy- × microdolichocephalic = microbrachycephalic than microdolicho- × microbrachycephalic = microdolichocephalic.

In families of the tab. 20 and 25 mibr × mido = mido and mido × mibr = mido, we find more sons than daughters (p. 59).

So we also accept that microdolichocephaly is dominant to microbrachycephaly but more strongly in the sons than in the daughters.

Phemonena of dominance, as has been said, are zygotic (p. 7). So according to the 1st scheme, there is dominance of brachycephaly to dolichocephaly in large heads and reversed dominance in small heads. The dominance is different for the two sexes. Macrobrachycephaly is more strongly dominant in the female, macrodolichocephaly more strongly dominant in the male.

In the 2nd scheme, the value of which is still to be examined, there

is a pair of factors A and a, where brachycephaly (mabr p. 19) is dominant to dolichocephaly (mido) and another pair of factors B and b where macrodolichocephaly is dominant to microbrachycephaly. It may appear that also here sex-differences are present, that the dominance of macrobrachycephaly is stronger for the male than for the female and of macrodolichocephaly stronger for the male than for the female.

Presently we shall further go into the significance of various dominance for the sexes in our material.

That the mean index of female is greater than the mean index of male is therefore in the first place a secondary character of sex, and in the second place also the differently strong dominance of macrobrachy- to macrodolichocephaly in female and in male and also the differently strong dominance of microdolicho- to microbrachycephaly in male and in female contribute to the fact that the mean index of female is greater than that of male.

In respect of the 2nd scheme the significance of the difference of the mean index, of the male and of the female has still to be fixed.

Our statistical results generally confirm the assumptions. The variability of children from parents with brachycephalic indices is greater than that of children from parents with dolichocephalic indices. The mean index of sons from parents with small heads is somewhat smaller than that of sons from parents with large heads. (tab. *l*, p. 51). Also the number of sons with dolichocephalic indices (tab. *k*, and *i*) is from parents with small heads greater than the number of sons with brachycephalic indices. However we do not find the standard deviation (tab. *l*, p. 51) of the index of sons from parents with small heads to be greater than from parents with large heads. It is very well possible that here non-hereditary variability (e.g. high index of the last child, p. 1) plays a part.

Formerly (1921, c, p. 23) we found that the variability of the index of children whose parents have brachycephalic indices, is greater than of children from dolichocephalic parents. From this it appears that the dominance of brachycephaly in the heredity of the headform comes to the front. Also the communications in the literature all speak of dominance of brachycephaly. In a further examination, when so great a material may be disposed of (especially of adults) as to make it possible that sub classifications of the material for sons and for daughters and

for large and for small heads may be formed, we may try to prove further statistically the differences of dominance accepted by us for male and female.

4. Patrocliny and matrocliny.

The various dominance we accepted just now for male and female, gives for a crossing and its reciprocal crossing only slight differences (tab. *m*).

We shall further examine these differences in our material for the crossings mabr × mado and mado × mabr and for the crossings mido × mibr and mibr × mido, that we may determine whether perhaps another propriety of the heredity of the headindex may be fixed.

For the examination of our material we have applied a special classification (p. 21). The material has been divided into groups, of which also the significance of the sex for the heredity of the index has been examined, and which may be regarded as samples at random (Chapt. III, p. 29).

The results in the different groups are divergent. It may be that, because the index is compound and because it admits of a great modification, the groups are too small.

We have therefore composed the tables *n*—*q*. Tab. *n* contains all families, the parents of which are brachycephalic and dolichocephalic, and also the families, the parents of which have differently high indices (thus indices which differ 1.5 and more index-units (p. 12). Tab. *o* contains the reciprocal matings. Tab. *p* contains the families, both parents of which are brachycephalic and differ less than 1.5 index-units [1]).

From tab. *m* (p. 53) ensues the following rule for crossings with varying dominance of a character for the male and the female, which we now wish to compare with the results of tab. *n*—*q*.

1. There are more crossings mabr × mado than mado × mabr.

2. There are more macrobrachycephalic indices among the daughters than among the sons and more macrodolichocephalic indices among the sons than among the daughters in both crossings.

---

[1]) Of families, both parents of wh.ch have brachycephalic indices and differ 1.5 or more index-units, the indices of the children have on the whole been taken up in the column dolichocephalic if they agree with the lowest index. The indices of the remaining children have been taken up in the column brachycephalic. Likewise for the families, both parents of which are dolichocephalic.

3. *a*. There are more macrobrachycephalic than macrodolichocephalic indices among the daughters in both crossings (mabr × mado and mado × mabr).

b. There are in the crossing mabr × mado among the daughters fewer macrobrachycephalic indices than in the reciprocal crossing.

4. *a*. There are more macrodolichocephalic than macrobrachycephalic indices among the sons in both crossings.

b. There are in the crossing mabr × mado fewer macrodolichocephalic than macrobrachycephalic indices than in the crossing mado × mabr.

1. We find in our material more matings mabr × mado than mado × mabr, viz respectively 46 and 34 matings (p. 23).

2. Tab. *n* shows us that the matings mabr × mado yield 36 % macrobrachycephalic daughters and 27.5 % macrobrachycephalic sons The matings mado × mabr yield according to tab. p. 47.5 % macrobrachycephalic daughters and 42.5 % macrobrachycephalic sons.

According to tab. *n* the matings mabr × mado yield 54 % macrodolichocephalic sons and 33 % macrodolichocephalic daughters and according to tab. *o* the matings mado × mabr 34.5 % macrodolichocephalic sons and 28 % macrodolichocephalic daughters.

So in both matings we meet more macrobrachycephalic daughters than sons and more macrodolichocephalic sons than daughters.

If the macrobrachycephalic and macrodolichocephalic indices among the children of the 3 other groups of matings from parents with brachycephalic and dolichocephalic indices, are added to those of the 1st group, as has been done in tab. *n*—*q*, we get the following result. We then find according to tab. *n* and tab. *o*, 19 % macrobrachycephalic indices among the sons and, 27 % among the daughters in tab. *n* and 28.5 % among the sons and 32 % among the daughters in tab. *o*. And for the macrodolichocephalic indices we find 35.5 % macrodolichocephalic indices among the sons and 21 % among the daughters in tab. *n* and 23.5 % among the sons and 23 % among the daughters in tab. *o*.

So we find in all matings of tab. *n* and tab. *o* more macrobrachycephalic indices among the daughters than among the sons and more macrodolichocephalic indices among the sons than among the daughters.

3. *a*. According to tab. *n* there are among the daughters 36 % macro

brachycephalic and 33 % macrodolichocephalic indices in the matings mabr × mado and according to tab. *o* there are 47.5 % macrobrachycephalic indices and 28 % macrodolichocephalic indices in the matings mado × mabr. So in both cases more macrobrachycephalic than macrodolichocephalic indices.

b. According to tab. *n*, mabr × mado, there are 36 % macrobrachycephalic indices and in tab. *o*, mado × mabr, 47.5 % macrobrachycephalic indices among the daughters. So in the matings mado × mabr there are more, which is in accordance with the 3rd rule.

Also for the whole material of tab. *n* and tab. *o*, there are more macrobrachycephalic than macrodolichocephalic indices among the daughters in both matings (27 and 21 %, 32 and 23 %). And in the mating mado × mabr there are more macrobrachycephalic indices among the daughters (32 %) than in the mating mabr × mado (27 %).

4. *a.* According to tab. *n* there are in the matings mabr × mado among the sons more macrodolichocephalic than macrobrachycephalic indices (54 and 27.5 % and for the whole material 35.5 and 19 %).

According to tab. *o* there are however contrary to the 4th rule, fewer macrodolichocephalic than macrobrachycephalic indices among the sons (34.5 and 42.5 % and for the whole material 23.5 and 28.5 %). So there are not, as rule 4*b* requires, more macrodolichocephalic indices among the sons in tab. *o* mado × mabr than in tab. *n* mabr × mado.

Now and then we have already met with this phenomenon and as has been said (p. 26, 28) it partly results from the difference between the mean index of female and that of male. If we look over the tables (column 2, tab. *n* and *o*) and their protocols (non-published), and compare the families, we see that fam. 34*b* of tab. 3 and fam. 335 and 32*g* of tab. 4, the mothers of which have all indices smaller than 80.7, contain, rather many macrodolichocephalic sons. Also fam. 21, 351, 182 and 268 of tab. 16 and 17 contain many macrodolichocephalic indices among the sons. In tab. *o* similar families do not occur. So we accept that the percentage of macrodolichocephalic indices among the sons in tab. *n* (54 and totally 35.5) is somewhat too high.

So the results of the matings mabr × mado and mado × mabr, as tab. *m* and *o* contain, point to the fact that macrobrachycephaly is especially dominant to macrodolichocephaly in female, to a less degree in male.

This result is in accordance with the result of the statistical research

on the variability of the indices of children from parents with brachycephalic respectively dolichocephalic indices.

According to tab. 12 and tab. 13 (1921*c*) of sons from brachycephalic parents $\sigma = 3.29$ (with omissions 3.24) and from dolichocephalic parents $\sigma = 3.08$ (with omissions 2.99). The difference is $\sigma br - \sigma do = 0.21$ (with omissions 0.25). For daughters $\sigma br = 2.975$ (with omissions 2.862) and $\sigma do = 2.31$ (with omissions 2.20); the difference is 0.66. So the variability of the index of children from brachycephalic and from dolichocephalic parents differs more in the daughters than in the sons.

That the mean index of female is higher than that of male is therefore partly due to different correlation of the dimensions and the index (tab. 19, 1922) and partly to various dominance of brachycephaly to dolichocephaly in female and in male.

The various dominance of macrobrachycephaly in female and in male and of microdolichocephaly in male and in female may also appear in the tables in another way.

If macrobrachycephaly is dominant to macrodolichocephaly in female and, to a less degree in male, there will appear among the matings mabr × mado = mabr (tab. 1) and also among the matings mabr × mado = mabr and mibr (tab. 2), more daughters than sons. And in the matings mado × mabr = mabr and mado × mabr = mabr × mibr there will likewise appear more daughters than sons. In the matings mido × mibr = mido + mado, there will be more sons than daughters.

Of all tables we have noted down the number of sons and daughters with their indices and united them into 3 groupes. The first group includes the tables where the children have only brachycephalic indices, the 2nd group includes the tables where the children have brachycephalic and dolichocephalic indices and the 3rd group includes the tables where the children have only dolichocephalic indices. Table *r* shows us that among the brachycephalic children there are more daughters and among the dolichocephalic children more sons.

In dealing with the different tables (Chapt. III) we have more than once pointed out the significance of the different number of sons and daughters in the different tables (e.g. tab. 20 and tab. 25).

Tab. *r*.

Indices of the Childern	Sons	Daughters	Sons	Daugthers
	N	N	%	%
brachycephalic	224	294	43.25	56.75
brachyc. and dolichoc.	464	514	47.5	52.5
dolichocephalic	102	96	51.5	48.5

This result is also an indication that macrobrachycephaly is more strongly dominant in female than in male and microdolichocephaly more strongly dominant in male than in female.

If we consider the crossings macrobrachy- × macrodolichocephalic and macrodolicho- × macrobrachycephalic with a view to matrocliny and patrocliny, it appears from tab. *n* that, where the mother is macrobrachycephalic, there are among the daughters somewhat more macrobrachycephalic than macrodolichocephalic indices; there are 52 % daughters; for the whole material of tab. *n* the percentage is 56. Tab. *n* also contains more macrobrachycephalic daughters than sons. For the sons we find in tab. *n* where the father is macrodolichocephalic, more macrodolichocephalic than macrobrachycephalic indices, viz 66 % (and for the whole material of tab. *n* 65 %) macrodolichocephalic indices. There are in tab. *n* more macrodolichocephalic indices among the sons than among the daughters.

So for the crossing mabr × mado there is according to tab. *n*, some inclination in the indices of the daughters to agree with those of the mothers and in the indices of the sons to agree with those of the fathers

In tab. *o*, where the index of the mother is macrodolichocephalic, there are fewer mado than mabr indices among the daughters. There are also fewer mado indices among the daughters than among the sons. In tab. *o*, where the index of the father is mabr, there are among the sons more mabr than mado indices and fewer mabr indices among the sons than among the daughters.

For the crossing mado × mabr, we find according to tab. *n* no indication of matrocliny and only a slight indication of patrocliny.

If we compare tab. *n* and tab. *o*, we see that in tab. *n*, where the mother is macrobrachycephalic ,there are among the daughters fewer mabr indices than in tab. *o*, where the mother is macrodolichocephalic In tab. *u*, where the father is macrodolichocephalic there are more mado indices among the sons than in tab. *o*.

This difference probably bears relation to the fact that tab. *n* mabr × mado, where the mother is brachycephalic, will contain more dolichocephalic indices among the sons, because the mean index of female is higher than that of male (p. 58). Probably it cannot be taken as an expression of patrocliny.

In tab. *o* where the mother is macrodolichocephalic there are among the daughters fewer macrodolichocephalic indices than in tab. *n*, where the mother is macrobrachycephalic (28 and 33 %; not for the whole material 23 and 21 %).

Also with this difference we must take into consideration that in tab. *n* mabr × mado, the number of dolichocephalic indices of the daughters perhaps tends somewhat upward, because the mean index of female is higher than that of male. So there is a slight indication of matrocliny.

In tab. *o*, where the father is macrobrachycephalic, there are among the sons more macrobrachycephalic indices than in tab. *n*, where the father is macrodolichocephalic. Also here we must take into consideration that the number of macrobrachycephalic indices among the sons in tab. *n* probably tends downward.

I think I may conclude that in our material, we find no or only an uncertain indication of patrocliny, respectively matrocliny in the heredity of macrobrachy- and macrodolichocephalic indices. (p. 64).

That in our material on the whole, in the heredity of the index no influence is present, particularly of the mother on the daughter and of the father on the son, appears from the result of our statistical research (1921, p. 24). We have found for the correlation of fathers and sons, $r = .202 \pm .024$, for fathers and daughters $r = .242 \pm .22$. So for fathers and sons we find a smaller coefficient of correlation (slighter heredity) than for fathers and daughters. The small coefficient of correlation of fathers and sons bears relation to the great variability of males. For mothers and daughters we find $r = .324 \pm .019$ and for mothers and sons $r = \pm .251 \pm .022$. For mothers and daughters we find a greater coefficient of correlation than for mothers and sons, perhaps not as an expression of matrocliny, but because the variability of the index of the sons is greater than that of the daughters.

For the heredity of the microdolicho- and microbrachycephalic index we find, in respect of varying dominance in tab. *n* and tab. *o* the following:

If microdolichocephaly is dominant to microbrachycephaly, especially in male, we must expect (Cf. tab. *m*, p. 000):

1. There are more crossings microbrachy- × microdolichocephaly than microdolicho- × microbrachycephaly.

2. There are more microdolichocephalic indices among the sons than among the daughters and more microbrachycephalic indices among the daughters than among the sons in both crossings.

3. *a*. There are more microdolichocephalic than microbrachycephalic indices among the sons in both crossings.

b. In the crossing microdolicho- × microbrachycephalic there are among the sons fewer microdolichocephalic indices than in the reciprocal crossing.

4. a. There are more microbrachy- than microdolichocephalic indices among the daughters in both crossings.

b. In the crossing microdolicho- × microbrachycephalic there are fewer than in the crossing microbrachy- × microdolichocephalic.

1. There are considerably more crossings microbrachy- × microdolichocephalic than microdolicho- × microbrachycephalic (28 and 12 matings).

2. In tab. *n*, microbrachy- × microdolichocephalic, there are among the sons more microdolichocephalic indices than among the daughters. Likewise in tab. *o*. For the whole material of tab. *n* and of tab. *o* the numbers are equal.

3. *a*. In tab. *n* microbrachy- × microdolichocephalic there are among the sons as many microdolicho- as microbrachycephalic indices. In tab. *o* microdolicho- × microbrachycephalic there are among the sons more microdolicho- than microbrachycephalic indices. For the whole material of tab. *o* the numbers are equal.

To the higher percentage of microdolichocephalic indices of the sons in tab. *o*, not much value must be attached. The numbers are small, and if we consider the different families, it seems possible that in fam. 32*c* and fam. 253, with almost only dolichocephalic indices, we have to do with dominance of microdolichocephaly.

3. *b*. In the crossing microdolicho- × microbrachycephalic, tab. *o*, there are among the sons more microdolichocephalic indices than in the reciprocal crossing microbrachy- × microdolichocephalic, tab. *n*. For the whole material of tab. *o* and tab. *n* the difference is very small

(23.5 and 22.5 %). This result is contrary to rule 3*b* for crossings with varying dominance for the male and the female.

4. a. Among the daughters there are in tab. *o* as many microbrachy- as microdolichocephalic indices; for the whole material there are more microdolichocephalic indices (38 and 38 %; 20.5 and 24 %). In tab. *n* there are more microbrachy- than microdolichocephalic indices among the daughters (45.5 and 33.5 %; 30 and 22 %).

4. *b*. In the crossing microdolicho- × microbrachycephalic, tab. *o*, there are fewer microbrachycephalic indices among the daughters than in the crossing microbrachy- × microdolichocephalic.

So the indications in the tables *n* and *o* for varying dominance for the two sexes in the heredity of microdolicho- and microbrachycephalic are slight. The numbers are small and there is paralyzing non-hereditary variability. Also the sum of headlength and headbreath is an insufficient indication for the headsize.

Certainly however there are in our material families with dominance of dolichocephaly and this dominance is not equal for the two sexes. Also in the tables this varying dominance manifests itself here and there (tab. 25, all children dolichocephalic p. 24f, 16 sons and 9 daughters, tab. 26 all children brachycephalic, p. 24f, 8 sons and 22 daughters.

In respect of matrocliny and patrocliny the matings microdolicho- × microbrachycephalic and microbrachy- × microdolichocephalic show according to tab. *n* and *o* the following.

In tab. *n* where the mother is microbrachycephalic, there are among the daughters more microbrachycephalic indices (45.5) than in tab. *o* where the mother is microdolichocephalic (38 %). For the whole material of tab. *n* and *o* these figures are 30 and 20.5 %. In tab. *o* where the mother is microdolichocephalic, there are among the daughters more microdolichocephalic indices (38 %) than in tab. *n*, where the mother is microbrachycephalic (33.5 %). For the whole material of tab. *n* and *o* these figures are 24 and 22 %. In tab. *n* where the father is microdolichocephalic there are among the sons fewer microdolichocephalic indices (40.5 %) than in tab. *o* where the father is microbrachycephalic (48 %). For the whole material these figures are 22.5 and 23.5 %. In tab. *o* where the father is microbrachycephalic there are among the sons fewer microbrachycephalic indices (39 %) than in tab. *n* where the father is microdolichocephalic (40.5 %). For the whole

material there is a small difference in inverse proportion (24 and 23 %).

So for the crossings microbrachy- × microdolichocephalic there are slight indications of matrocliny. If we take into consideration the small number of crossings, by which some families (e.g. fam. 19 tab. 28, which may be a case of dominance of microdolichocephalic) may have a great influence on the final result, we may attach only small value to the result.

The phenomenon of matro- and patrocliny has been more than once observed with mendelian segregations. One has tried to explain the divergent numbers of segregation by partly sex-linkage. For his experience with Drosophila BRIDGES sought for a more satisfactory explanation and calls non-disjunction the assumption that now and then combinations of factors do not disjoin in the forming of the zygote, but pass into the form as they were present in the mother, respectively in the father. In this way there appear among the daughters more individuals corresponding with the mother and among the sons more individuals corresponding with the father. So non-disjunction is a phenomenon of sex-linked inheritance. BRIDGES gives a survey of the literature of the mendelian segregations which may be explained in this way. Also A. VON TSCHERMAK (1919, p. 359) found that in his experiments with fowls, the daughters agree with the mother and the sons with the father.

If we accept that non-disjunction takes place for the factors of heredity of the headform, this will happen for the factors A and B as well as for C and D. To determine this quality in the material we may therefore join the macro- and microbrachycephalic and macro- and microdolichocephalic indices. If we do so, we find among the daughters 57 % brachycephalic indices in tab. *n* and 53 % in tab. *o*, and among the sons 58 % dolichocephalic indices in tab. *n* and 47 % in tab. *o*. These figures indicate what may be expected in the case of non-disjunction. They are not to be attributed to the influence of the composition of the tables, i.e. of the fact that the mean index of the female is higher than that of male. If we take this influence into account, the percentage of brachycephalic sons in tab. *n* becomes greater through it and the percentage of dolichocephalic sons smaller,, and so will differ less from the corresponding figures of tab. *o*. However the number of brachycephalic daughters also becomes greater than in tab. *n* and the number of doli-

chocephalic sons smaller. Through this, the differences with the corresponding figures of tab. *o* becomes still greater.

Already before (1919, p. 358, 359) I draw the attention to this phenomenon.

BRYN (1920 p. 209) finds something like that: The sons are markedly more pronounced brachycephalic than the daughters in the cases where the brachycephaly is due to the father, whereas in the cases where the brachycephaly is due to the mother, the daughters are more pronounced brachycephalic than the sons (p. 61).

Tab. *p* and tab. *q* give a survey of the crossings brachy- × brachycephalic and dolicho- × dolichocephalic. They have been composed in the same way as the tab. *n* and *o*.

If there is varying dominance, the crossing macrobrachy- × macrobrachycephalic may be represented by the formula AA × AA = AA and Aa × AA = Aa + AA + Aa + AA, of which one half of the number of indices of the sons is dolichocephalic. The crossing macrodolicho- × macrodolicho-cephalic may be represented by the formula BB × BB = BB and BB × Bb = BB + Bb + BB + Bb, of which one half of the number of indices of the daughters is brachycephalic. There follows from the formulae that with varying dominance the number of matings macrobrachy- × macrobrachy-cephalic is as large as the number of matings macrodolicho- × macrodolichocephalic.

In the heredity of the index the number of matings macrobrachy- × macrobrachycephalic is greater than the number of matings macrodolicho × macrodolichocephalic, because macrobrachycephaly is dominant to macrodolichocephaly but more strongly in female than in male.

Tab. *p* contains in the matings macrobrachy- × macrobrachycephalic among the sons 34.5 % macro-dolichocephalic indices and among the daughters 41 %. For the whole material of tab. *p* these figures are 27 and 22 %.

The number of families is small, the distribution of the indices among the children is different. As for the deviating number of macrobrachycephalic sons, it is of importance that of fam. 376 with 7 sons and 1 daughter (tab. 14), 6 sons have brachycephalic indices. We want to observe here further that fam. 209 of tab. 62 (p. 25,m) contains 4 sons with macrodolichocephalic indices and only 1 son with a macrobrachy-

cephalic index. Fam. 171 of tab. 62 contains 3 macrobrachycephalic daughters and no macrodolichocephalic. Here, with a relatively small number of families, one single extreme family influences the final result one-sidedly.

Tab. *q* contains in the matings macrodolicho- × macrodolichocephalic among the daughters more macrobrachycephalic indices than among the sons. For the whole material the figures are 29 and 23 % The numbers are however here so small that only very little value to this result may be attached. So we find among the matings macrobrachy- × macrobrachycephalic and macrodolicho- × macrodolichocephalic slight indications of a various dominance in male and in female of macrobrachycephalic.

As for the crossings microdolicho- × microdolichocephalic and microbrachy- × microbrachycephalic, the number of matings microbrachy- × microbrachy cephalic amounts to 25, and the number of matings microdolicho- × microdolichocephalic to 20 (55.5 and 44.5 %). The number of matings macrobrachy- × macrobrachycephalic is 46 and the number of matingsmacrodolicho- × macrodolichocephalic is 28 (62 and 38 %). So there are relatively more matings microdolicho- × microdolichocephalic than macrodolicho- × macrodolichocephalic. This proves for an experience ot dominance of microdolichocephaly.

The number of microdolichocephalic indices is in the crossings microbrachy- × microbrachycephalic among the sons somewhat greater than among the daughters (tab. *p* 21.5 and 20 %). The great number of microdolichocephalic indices among the sons in the group microbrachy- × microbrachycephalic is caused by fam. 271 with 5 microdolichocephalic indices and not a single microbrachycephalic index; both parents in this family have low indices, 80.5.

The number of microbrachycephalic indices is in the crossings microdolicho- × microdolichocephalic among the daughters somewhat greater than among the sons (tab. *q* 30 and 27 %).

The number of these crossings are so small that also here to these results only slight value may be attached.

So we find for the crossings microbrachy- × microbrachycephalic and microdolicho- × microdolichocephalic a slight indication of various dominance for male and for female of microdolichocephaly. That the percentages for the different indices in tab. *p* and *q* generally differ so little, may serve as a support for the conception that the index is a

compound character and that its heredity rests upon the presence of multiple factors. In the figures of the matings dolicho- × dolichocephalic like in those of the matings brachy- × brachycephalic of tab. *p* and *q* is especially shown that the mean index of female is higher than that of male.

CHAPTER V

DISCUSSION AND CONCLUSIONS

.... die Wege zu erschauen,
auf welchen die Erkentniss fort-
schreitet. MACH.

In the manner as the material in the foregoing investigation has been dealt with, thus on the basis of the polymery theory, the terms brachycephaly and dolichocephaly have undergone some alteration. We now speak of factors for brachycephaly, resp. for dolichocephaly and understand by them factors, increasing, resp. decreasing the index with a certain amount. Thus indices contain factors both for brachycephaly and for dolichocephaly. The extremely high and the extremely low indices alone, contain factors only for brachycephaly, resp. for dolichocephaly. The terms brachycephaly and dolichocephaly, as used otherwise, thus in the sence of indices being greater, resp. smaller than 80, represent compound magnitudes: a brachycephalic index is brought about through the presence of some factors for brachycephaly. The same indices may be different compositions of factors.

The appearance of small headsizes among the children in families, both parents of which have large heads, resp. of large headsizes where both parents have small heads, immediately follows from our assumption, that the heredity of the headsize rests on multiple factors, together with the heterozygotes being intermediate. In large heads f.i. there will always be some factors present in the heterozygous form, which factors in the crossing will therefore yield also small heads. In the group macrobrachy- × macrobrachycephalic f.i. we shall therefore meet few families with many children, which all have large heads (tab. 1), more families however, where the children have both large and small headsizes (tab. 2,) a.s. o. Besides there is with respect to the headsize a high degree of non-hereditary variability.

We shall rarely meet with one phenomenon of heredity of the cepha-

lic index in a family. In the instances where the indices of the parents are simply composed ,so that many pairs of factors of heredity are the same and homozygous, one group of factors may characterize the indices of the children. One group of factors for brachycephaly and one for dolichocephaly f.i. (nAA × nBB), shows then dominance of brachycephaly; one group of factors in both parents in a heterozygous form (nAB × nAB) shows segregation, a.s.o.

The compound construction of the indices prevents most times that there are such simple phenomena of dominance or of segregation. If e.g. in tables of families which show segregation so according to the formulae AB × AB, or CD × CD, the crossings AA × BB appear, the indices of the children will increase and if the crossings CC × DD appear, they will decrease.

The study of the different families, as they are ranged in the tab. 1—74, teaches us that in the heredity of the headindex dominance presents itself, viz of macrobrachycephaly to macrodolichocephaly and of microdolichocephaly to microbrachycephaly.

If in matings where dominance of brachycephaly occurs, the latter could be represented by the formula DD × RR = DR, we would expect that both grandparents of the brachycephalic parent are both brachycephalic.

In the tables bearing upon this mating, there are some families where both grandparents are not macrobrachycephalic. In our 2nd study (1921*c*, chapt. 3) we have accepted prepotency in these families. We have seen that the heredity of the index in these families may also be explained full well by multiple factors and dominance of macrobrachycephaly (p. 45).

Also the surpassing of the indices of the parents in an upward or downward direction by the indices of the children may be explained full well by the assumption of multiple factors and reversed dominance (p. 6). We found it confirmed in our investigation of the different matings (not published). Besides prepotency may occur as a physiologic character of the zygote.

We have accepted many non-identical, but little different, factors to explain the hereditary differences of the indices, while the factors often appear in groups. In this manner great differences among the indices of the children may be explained. The passing into groups of factors takes in the place of mutually very different factors. A good

example we met in fam. 179*d*. Likewise with the headsize the passing of factors into groups occurs. (e.g. fam. 130,). In this way can also be explained, that a deviating index or headsize of one of the parents or grandparents occurs among the children. In our formulae we regularly meet with groups of terms; in reality the cases will be rather rare.

We have accepted factors for the form and not for the dimensions of head separately. (p. 1—5).

Besides factors for the index, thus for the form, there are factors for the size.

We have not chosen factors exercising influence both on form and size together. (p. 11). The fact that the alteration of form is not always brought about in the same way when the size alters, namely that the correlations between length, breadth and height in large heads differ from those in small heads, cannot be expressed in this scheme. Neither is this possible for the phenomena of dominance for large and for small heads. Also the fact, that in the heredity of the headsize the heterozygotes are probably intermediate, while the heredity of the form (index) shows phenomena of dominance, is contrary to this scheme.

In my opinion the principles applied in this paper meet in the simplest way the relation between form and size.

There are equal numbers of multiple factors for the headform and for the headsize. Form and size have a close cooperation.

I think that strictly speaking, with investigations of heredity of dimensions, we must always take into account the correlation of the dimensions. So we must not examine the heredity of leaflength and of leafbreadth, but of the lengthbreadth index in connection with the size. In the same way it is better to investigate the index of beans and not the dimensions (LEITCH, 1921). There are form units and size units, and in equal numbers.

W. SCHEIDT (1923, p. 99) and E. FISCHER (1924, p. 38) would moreover like to accept the heredity of the dimensions of head.

Another remark about our factors of heredity we make in consequence of JOHANNSEN's criticism (1907) on the use made by anthropologists of the headindex.

In our first study (1922, p. 511) we have largely dealt with JOHANNSEN's paper.We could give to JOHANNSEN's experience on the significance of the headlength for the index, which was already made by BOAS, a general significance. We think that for different classes of

length the index is different, because great length is accompanied by greater height and in a less degree by greater breadth and small length by greater breadth and in a less degree by greater height. Similar rules may also be laid down for the breadth and for the height (1922, p. 526).

Now JOHANNSEN wishes to correct the rough indices by determining for each class of length the mean index, and by increasing or decreasing a given index by the difference between the mean index of the whole material and the mean index of the class of length to which the given index belongs. JOHANNSEN demonstrates this for his pure lines of beans, but remarks that also to populations this correction may be applied because in all pure lines the phenomenon is present, be it in a different measure.

What we have done, comes to the very thing as what JOHANNSEN wishes. On determining the formula for the index, we have in each given case taken into account the size of the head, and determined according to it the number of A and C, respectively B and D factors. A and B factors represent a different correlation between length, breadth and height than C and D factors.

We have accepted that A and B factors increase respectively decrease the index by 1.5 units, and the C and D factors by 2 units. So in our scheme the index is represented by a different formula according to the headsize, the rough indices are corrected in connection with the headsize.

On account of the presence in the formulae of the indices for different classes of dimensions of a different number of A and a, B and b, and C and c factors (p. 15), also the second scheme would be able to explain the difference between the mean indices of the classes.

Every dimension of head is composed of three elements according to the 2nd scheme. Headlength f.i. is increased by B factors, a factors and c factors. For different length classes the number of these factors is different and therefore the mean index of the different length classes is also different. The same is true for the breadth and for the height.

In the phenomenon of JOHANNSEN we have the direct refutation of the opinion of JOHANNSEN that the dimensions are „fundamentale Fakta" (1921*c*, p. 196). Form-units are elementar facts.

As to the connection of index and capacity we have found in our material that there is no sensible correlation between index and capacity. We found (1922, p. 527) $rm = -0.036$, $rf = -0.0235$, and (1921*c*,

p. 248) that the mean index of small heads is a little larger than of large heads. We remember also the results of PEARSON and others (1922, p. 532).

This finding of no sensible correlation between index and capacity may be in accordance with our idea that there are different sets of factors for high and for low indices with large and with small heads. (A and B, C and D factors, p. 13).

When we look at the case more closely then there is some difference. Macrobrachycephaly is dominant to macrodolichocephaly; microdolichocephaly is dominant to microbrachycephaly. The dominance of macrobrachycephaly is with the female more evident than with the male; of microdolichocephaly the dominance is stronger for the male than for the female.

With large heads the heterozygotes will have in the female a little higher mean index than with small heads. And in the male the heterozygotes will have with small heads a little lower mean index than with large heads. There would be then a small positive correlation between index and capacity. We did not find it. We found a very small negative correlation. In tab. 1 we found that in the males the mean index of large heads is a little higher than in small heads (p. 51).

BRYN (1920) accepts for a small material three biotypes, one for brachycephaly, one for mesocephaly and one for dolichocephaly, in which cases brachycephaly is dominant to mesocephaly and to dolichocephaly, while dolichocephaly is dominant to mesocephaly.

At the beginning of my study, I wished to accept for my material that microbrachycephaly was hypostatical with respect to macrobrachy- and dolichocephaly (1917, p. 874). In my further examination this assumption met with too great difficulties. (Families microbrachy- × microbrachycephalic did not yield only microbrachycephalic children; c.f. fam. 3*d* p. 000. Besides we do not find microbrachycephaly as extracted recessiveness from large heads).

The hypothesis of BRYN seems to me to have only a provisional value.

BRYN involves also observations of JÖRGENSEN in his examination and finds there (tab. 12 and 13) no dominance of brachycephaly. He thinks it most probable, that the dolichocephalic part of the parents is in this case only phenotypically dolichocephalic. It is possible that also

in the material of Tydalen and the Faroes varying dominance of brachycephaly is present in the way as accepted here [1]).

It is certain that sex is of importance for the heredity of the headform The mean index of female is higher than that of male, partly as secondary character of sex. What further contributes to this difference could not be defined with certainty. The different tables 1—74 (chapter III) of themselves have not yielded certain results. If we look over the families of the different tables, the great differences will sometimes appear.

The investigation of tab. f, g (Chapt. II, p. 26, 27) and of tab. *n—q* (Chapt. IV, p. 56) has taught us that the heredity of the index in male is not quite the same as in female. We can best explain the difference as different dominance of macrobrachycephaly to macrodolichocephaly and of microdolicho- to microbrachycephaly.

There are also some indications for the assumption of matrocliny and patrocliny taken as non-disjunction (BRIDGES).

For the greater variability of the index in male than in female we are still in want of the mendelian explanation.

We have not reckoned with the differences we found of dominance in female and in male in drawing up our formulae.

We have accepted for the headsize that the heterozygotes are intermediate (p. 11, 12). We insert here the discussion of tab. *r*, composed of our material that gives us some indication yet on the heredity of the headsize.

Table *r* has been brought about in the following way. Let us consider a family, for which the formulae have been drawn up, e.g. fam. 243, (not published). Each family contains, as we know, 19 factors. If we compare in this case the formulae of the parents, we see that AA factors always come together with AA factors and BB factors, likewise DD factors with CC factors and DD factors. So each factor for the father and for the mother indicates the same headsize. Of course it may occur in other cases that AA sometimes comes together with CC, BB with DD a.s.o., so that therefore a factor for the parents indicates a different headsize. This been has investigated and noted down for each family, and columns 5—7 of tab. *r* indicates the results.

For tab. 1—5 we find, that in 20 families for which the formulae have

---

[1]) SCHREINER (1923).

been drawn up, 27 times, a factor gives a different headsize for the parents. As each formula contains 19 factors, the factors of the formulae of the parents may 19 times show different headsizes; thus for tab. 1—5 20 × 19 = 380 times. So in tab. 1—5, 27 : 3.8 = 7.11 % of the cases, different factors for the headsize occur in the parents.

For the children we see in columns, 2—4 of tab. *r* that in fam. 243, the first factor is 2 times AA and 5 times CC, thus 2 times there is a deviating headsize. The 2 nd factor is 2 times CC and 5 times AA; thus here also a deviating headsize is found 2 times. In this way we find how many times for all factors a deviating headsize occurs. In columns 2—4 of tab. *r*, we see, that in tab. 1—5 in 88 children of 20 families, 95 times a deviating headsize occurs. As each factor may deviate, we calculate the percentage of deviations thus: $95 : \frac{88 \times 19}{100} =$ $= 5.68$.

We learn from tab. *r*, that the tab. 1—35 where according to our definition both parents have the same headsizes, in 8 % of the cases the deviating headsize appears. In the tab. 36—74 where both parents have different headsizes, the percentage of the deviating headsize amounts to 15. These two percentages 8 and 15, show us in what measure the headsizes of the parents in both large groups of families (tab. 1—35 and tab. 36—74) differ (p. 22).

As for the headsizes of the children, we learn from tab. *r*, that in the tab. 1—19, where both parents have large heads, in 5.89 % of the cases a deviating headsize occurs, in tab. 20—35 where both parents have small heads, this percentage is 6.03. Of families where both parents have large heads, the number of cases, that the factors indicate a different headsize, is about as large as of families where both parents have small heads (5.89 and 6.03 %). This result points out, that in the heredity of the headsize the heterozygotes are intermediate.

Tab. 36—74 contain the families both parents of which have different headsizes. Here the percentage of divergent headsizes among the children is somewhat greater than in the foregoing group and on an average 6.99 %. This result may have the following significance.

In the group where both parents have large heads, parents occur with very large heads down to parents with heads somewhat larger than mediocrely large. If we call the factor for a large head A, for a small head B, we shall find especially the formulae AA and AB. In the

group where both parents have small heads (tab. 20—35) we shall find especially the formulae BB and AB. These formulae yield the following matings AA × AA = AA, AB × AA = AB + AA, AB × AB= = AA + 2AB + BB, and BB × BB = BB, AB × BB = AB + BB, AB × AB = AA + 2AB + BB.

When there is no dominance, we must expect in both groups the same number of different headsizes (we find 5.80 and 6.03 %).

In the group where both parents have different headsizes (tab. 36—74) we find the matings AA × BB = AB, AB × AB = AA + + 2AB + BB, AA × AB = AA + AB, and AB × BB = AB + BB. In this group (tab. 36—74) we find more heterozygotes than in the first group (tab. 1—35) in the relation, of 15 : 12 and as in heterozygotes a greater variability is found, the greater percentage of different headsizes may be explained by it.

If the heredity of the headsize was not intermediate, but if e.g. the large head was dominant over the small head, then in the families where both parents have large heads would appear the formulae AA × AA, AA × AB, and AB × AB, and in the families where both parents have small heads only the formulae BB × BB and perhaps sometimes the formulae BB × AB and AB × AB. The number of children with different headsizes would in both cases not be equal.

In the whole material (p. 22) we have applied 6.4 % inversions (of A in C, B in D); 5.95 % in the families, where both parents have the same headsizes and 6.99 % in the families, where both parents have different headsizes. This is not a very great number. Neither were most times great the difficulties we experienced in drawing up the formulae for the indices of the different families. The reason for it is that the formulae in many cases have only a provisional value. As of most families we know only two generations (parents and children) there is nearly always a great possibility to select the formulae. Are three generations of a family known, the drawing up of the formulae is more difficult and the formulae of the parents are determined from one side by the children and from the other side by the grandparents.

If after a number of years we could complete the families with a new generation, in many formulae alterations had to be made. The manner we followed is quite the same as that which is applied in making breeding tests. Also here we often begin with drawing up a provisional for-

mula, that is altered by the results of following cultures and thus obtains a higher degree of security.

Most probably there appear in our material in the formulae of the parents more factors in a heterozygous form than we have accepted and surely the different terms of the formulas of the parents will come together in a more irregular way.

SCHREINER's conclusions (1923) are grounded on the experiences of the difficulty of the investigation of the heredity of the headform (p. 445). The index is taken as a poor means to express the headform and the attention is drawn to the significance of the integral parts of the skull for the heredity. Finally the conclusion is that the headform has come about by a cooperation of different factors of heredity, and also of other moments, the nature and significance of which are still to be investigated.

My conclusion is not so little hopeful. The heredity of the headform is a problem of anthropological, biological and also practical significance being compound but of which we are able however to indicate a direction in which the investigation has to be taken.

The headindex i.e. the length-breadth index is an important means of expressing the headform. That we may still further determine its significance, it will be necessary to examine the heredity of the three headindices.

So far the investigation has taught us that brachycephaly is dominant to dolichocephaly. In the second place there is also dominance of dolichocephaly to brachycephaly. This is not simply reversed dominance. But here different pairs of factors are active.

We may have to deal either with multiple pairs of factors A and B for brachycephaly and dolichocephaly in large heads, being active as C and D factors in small heads, or with pairs of factors A and a for brachycephaly and dolichocephaly, being active as factors for greater and smaller breadth and at the same time for smaller and greater length and height, factors B and b for dolichocephaly and brachycephaly, being active as factors for greater and smaller length and at the same time for smaller and greater breadth and height, and factors C and c for hypsicephaly and chamaeocephaly, being active as factors for greater and smaller height and at the same time for smaller and greater breadth and length. All three pairs of factors have besides their princi-

pal effect on one index, at the same time secondary effects on the other indices (tab. c, d, p. 16).

In both schemes the results of the investigation of the heredity that there is dominance of brachycephaly but also recessiveness find their places.

A serious objection against the second scheme is, that the variability of the indices of children of brachycephalic parents is larger than that of dolichocephalic parents, or in general that dominance of brachycephaly occurs much more times than that of dolichocephaly. Therefore is no ground according to the 2nd scheme, where A (macrobrachycephaly, broad) is dominant to a (microdolichocephaly, narrow) and B (macrodolichocephaly, long), dominant to b (microbrachycephaly, short). According to the first scheme this objection does not exist, dominance of dolichocephaly only occurs there with small heads (ii), and there are much more II and Ii than ii combinations.

According to the 2nd scheme and with normalized heads (p. 18) the short brachycephalic head will contain many bb terms. The headlength will be little variable here. In the same way the narrow dolichocephalic head will contain many aa terms; so the headbreadth will be here little variable. When there will be gathered good material, then diverse questions with respect to the 2nd scheme may be inquired, of which the solution will contribute to the knowledge of the cephalic index (p. 19, 20.)

Also with respect to the relation between index and sex the investigation has so far yielded something. The phenomena of dominance are different for the two sexes.

My conclusion is that with the investigation of the heredity of the headform, we are in the way of the development of the experimental mendelian research, that these investigations therefore also contribute to that development and that conversely from the results which the mendelian experimental research yields on so many a domain may be expected, that continued investigations of the heredity of the headform in a sence as applied here, will also yield results for the knowledge of that heredity. moreover results of hereditary researches cast light on facts that are already known and got by other methods.

The significance of the cephalic index rests in its being a hereditary property. A. RETZIUS intuitively accepted this heredity.Through scientific research it must be known.

At the end of the manuscript I got acquainted through a treatise of

E. FISCHER (1924) with the publications of AUERBACH (1912), SZOMBATHY (1918) and HAUSCHILD (1921). They confirm my opinion that my researches participate in the development of the index problem. AUERBACH (1912) writes after rejecting the objections that were raised from anthropological side against the cephalic index: „.... für die anthropologische Wissenschaft bleibt die Verpflichtung bestehen die Schädelform, die sie zur Grundlage von Einteilungen und Untersuchungen macht, auch positiv als ein konstantes und vererbbares Merkmal zu erweisen." Then AUERBACH points to the difficulties that are connected with taking up the cephalic index as „Erbeinheit", and reminds us of the double nature of brachycephaly as shortheadedness and wideheadedness and of dolichocephaly as narrowheadedness and longheadedness. WALDENBERG (1902) already used to speak of eurycephaly (wideheadedness) and brachycephaly (shortheadedness) and of dolichocephaly (longheadedness) and leptocephaly (narrowheadedness).

SZOMBATHY (1918) draws the attention to the significance of the normalised head. As such he takes the cubic contents of the skull at 1000. By SZOMBATHY's method long, narrow, wide and short skulls were taken apart. A group of brachycephalic skulls may be divided into two groups, short and wide ones. It is clear that what SZOMBATHY takes as possibility here, was taken as a requirement by me in applying the 2nd scheme (p. 18). Likewise FISCHER (1921, S. 442) draws the attention to the possible significance of SZOMBATHY's method for biological questions.

HAUSCHILD's research (1921) is the second in which he discusses the heredity of the headform. His first research (1916) I discussed in my second study on the heredity of the headform (1921, p. 195). I said there of that investigation that it is not dear, that some conclusions are deficient and that I can attach little value to it as mendelian work. Now that I have read HAUSCHILD's second research (1921) I think I see some correspondence in his considerations with my ideas in my second scheme. HAUSCHILD however thinks the dimensions of head in themselves may suffice for a scheme of heredity and he does not distinguish in the value of each dimension of head the share of the headsize and of the headform.

I arrive at the conclusion that further investigation according to the rules of AUERBACH, SZOMBATHY, HAUSCHILD and myself will promote our knowledge of the heredity of the headform and the significance of the headindex.

SUMMARY

The heredity of the headform must be expressed by factors for the form. Factors for the three dimensions of head of themselves cannot explain the heredity of the headform.

The heredity of the headform and that of the headsize are independent. There are factors of heredity for the headform and for the headsize. The factors for the headform show dominance, of those for the headsize the heterozygotes are probably intermediate.

For the heredity of the headform and that of the headsize we have accepted an equal number of multiple (polymere) factors.

For the heredity of the headform there is moreover multiple allelomorphism.

In the heredity of the headform we find dominance and sometimes also recessiveness of brachycephaly. There are also differences for the two sexes.

We have given two mendelian schemes which can explain the heredity of the headform. The first scheme we have applied to our material.

The two schemes are based on multiple allelomorphism and polymery.

In the first scheme we accept as first allelomorphic pair of factors A and B, which increase, respectively decrease the index by a certain amount, 1.5 index-units. This pair of factors is polymere; we have accepted 19 non-identical pairs of factors.

The factors A and B are active in large heads, so together with factors I, which increase the head-capacity by a certain amount. The factor A for brachycephaly is dominant to factor B for dolichocephaly.

As second pair of allelomorphic factors we distinguish factors C and D, which increase, respectively decrease the index by a greater amount, 2 index-units. It is active in small heads. Properly speaking it is not a different pair of factors, the activety is different, in as much as by the influence of the small head (ii), the effect on the index is altered and

the dominance is reversed. The factor D for dolichocephaly is dominant to factor C for brachycephaly.

In the second scheme we accept 3 allelomorphic pairs: A and a, B and b, C and c, which are all polymere. Each pair occurs in a different number. Together there is an equal number of pairs as for the headsize.

Each factor has a principal effect on one dimension of head and secondary effects on the two other dimensions, so that the headform is altered in different sense and the headsize remains unaltered.

The factor A, which especially increases the breadth, is dominant to a, which especially decreases the breadth, B, which especially increases the length, is dominant to b, which especially decreases the length, C which especially increases the height, is dominant to c, which especially decreases the height.

Also for the factors of the second scheme a different effect for larges and small heads may be accepted.

So according to the first scheme there is dominance of brachycephaly with large heads and dominance of dolichocephaly with small heads. The dominance of brachycephaly is stronger in the female and dominance of dolichocephaly in the male. There are sets of factors that only differ in a quantitative sense.

According to the 2nd scheme macrobrachycephaly (broad) is dominant to microdolichocephaly (narrow) and macrodolichocephaly (long) is dominant to microbrachycephaly (short). With the 2nd scheme there are really different sets of factors.

The significance of the sex for the heredity of the headform shows itself as secondary character of sex and as different dominance of brachydephaly to dolichocephaly for the male and the female. Perhaps there is patrocliny and matrocliny, which phenomenon as non-disjunction may find its explanation.

In following investigations of families on the headform, also the headheight will have to be measured so that we can determine the 3 indices of the headform and know the headsize. We want especially observations of all three dimensions of head. Still more material is also wanted, so that we dispose of many families with only adult children and that we may calculate from a large number of non-adults of every age exact values, that reduce the index of the non-adult in a good serviceable calculated index of the adult.

LITERATURE CITED

1912. T. R. Arkell and C. B. Davenport. Horns in sheep as a typical sex-limited character. Science N. S. 35, p. 375.

1912. E. Auerbach. Zur Plasticität des Schädels, mit Bemerkungen über den Schädelindex. Arch. f. Rassen- u. Gesellschafts-Biologie. Bd. 9, S. 604.

1913. W. Bateson. Mendel's Principles of Heredity. Cambridge.

1899. F. Boas. The cephalic index. American Antropologist. Vgl. 1. p. 448.

1920. L. Bolk. Over den Index cephalicus en de absolute Maten van het Hoofd der Bevolking van Nederland. Versl. k. Ak. v. Wet. p. 969. Wis- en Natuurk. afd. Dl. XXVIII. N. 9.

1916. C. B. Bridges. Non-disjunction as proof of the chromosome theory of heredity. Genetics I. p. 1 and p. 107.

1920. H. Bryn. Researches into anthropological Heredity. Hereditas. Vol. 1, p. 186.

1916. W. E. Castle. Size inheritance in Guinea-pig crosses. The proceedings of the Nat. Acad. of Sc. Vol. 2, p. 252.

1921. W. E. Castle. On a method of estimating the number of genetic factors concerned in cases of bleuded inheritance. Science N. S. 34, p. 93 and p. 223.

1917. Ch. B. Davenport. Inheritance of Stature. Eugenics Record Office. Bull. N. 18.

1921. E. Fischer. Bücherbesprechungen. Z. f. Morph. u. Anthr. Bd. 21, S. 442.

1923. Eug. Fischer. Schädelform und Vererbung. Münchener medizinische Wochenschrift. Nr. 50, S. 1475 und 1476.

1924. Eug. Fischer. Betrachtungen über die Schädelform des Menschen. Zeitschrift für Morphologie und Anthropologie. Bd. XXIV.

1917. G. P. Frets. On Mendelian segregation with the Heredity of Headform in Man. Proceed. R. Acad. of Sc. Amsterdam. Vol. XX p. 435 and p. 865 (Dutch. Vol. 26, p. 367 and 946).

1919. G. P. Frets. De erfelijkheid van den hoofdvorm. Handelingen van het Nat. en Geneesk. Congres. Leiden. April. 1919. p. 350—359.

1920. G. P. Frets. De polymerietheorie getoetst aan de erfelijkheid van den hoofdvorm. Genetica. II, p. 115—136.

1921*a*. G. P. Frets. Erfelijkheid, correlatie en regressie. Genetica. Bd. III. p. 1—28.

1921*b*. G. P. Frets. Erfelijkheid en Selectie. Handelingen van het Nat. en Geneesk. Congres. Utrecht, p. 136; Maart 1921. (Compl. in Ned. Tijdschr. v. Geneesk. 1921. II, p. 956—976.)

1921*c*. G. P. Frets. Heredity of Headform in Man. (2 nd. study on the material) Genetica. Vol. III (p. 193—400) with 16 tables. Also Martinus Nijhoff. The Hague. 1921.

1921*d*. G. P. Frets. Les méthodes pour rassembler le matérial en vue des recherches sur l'héredité chez l'homme. Compte-rendu de la session de Liège de l'Inst. d'Anthropol. Revue anthropol. 31 ann. p. 448. 1921.

1922 [1]). G. P. Frets. The index cephalicus. (1. study on the material). Genetica, Vol. IV. p. 481—534.

1922*a*. G. P. Frets. Het Mendelisme en zijn beteekenis voor de geneeskunde. N. T. v. Gen. II, p. 546.

1923. G. P. Frets. Mendelismus und Medizin. Studia Mendeliana. S. 60—65. Festschrift für Mendel.

1923. J. H. Gerould. Inheritance of white wing color, a sex-limited (sex-controlled) variation in yellow pierid butterflies. Genetics. Vol. 8, p. 495.

1922. R. Goldschmidt und E. Fischer. Argynnis paphia-valesina, ein Fall geschlechtskontrollierter Vererbung bei Schmetterlingen. Genetica Vol. 4, p. 247.

1916. M. W. Hauschild. Das Mendeln des Schädels. Z. f. Ethn. 48. Jhrg. S. 35—40.

1921. M. W. Hauschild. Die Göttinger Gräberschädel Zeitschr. Morph. Anthr. Bd. 21. H. 3.

1907. W. Johannsen. Ueber Dolichocephalie und Brachycephalie. Arch. f. Rass. Ges. Biol. S. 171.

1913. W. Johannsen. Elemente der exakten Erblichkeitslehre. Jena. G. Fischer.

1902. F. Jörgensen. Antropologiske Undersökelser fra Faeröerne. Kjöbenhavn. (cit. by Bryn).

1912. Lewandowsky. Handb. f. Neurologie. Bd. III. S. 20.

1914. E. C. Mac Dowell. Multiple factors in Mendelian Inheritance. Journ. of exp. Zool. Vol. 16. 1914, p. 177.

1914. F. H. Morgan. Sex-limited and sex-linked inheritance. Am. Nat. Vol. 48, p. 577.

1909 u. 1911. H. Nilsson-Ehle. Kreuzungsuntersuchungen an Hafer und Weizen I und II. Acta Universitatis Lundensis. Lund.

1902. A. Nyström. Uber die Formenveränderungen des menschlichen Schädels und deren Ursachen. Arch. f. Anthrop. Bd. 27. S. 211, 317, 623.

1915. M. M. Orensteen. Correlation of Anthropometrical measurements in Cairoborn Natives. Biometrika XI, p. 67.

1911. R. Crewdson Benington and K. Pearson. A study of the Negro Skull. Biometrika XIII p. 292.

1916. Jur. Philiptschenko. Variabilité hérédité du crâne chez les Mammifères.

---

[1]) This investigation has been cited in a former paper under the title: Variation and correlation of the human head. Transactions of the Royal Acad. of Sciences. Amsterdam. 1920. Circumstances have prevented the paper to appear there.

Archives Russes d'Anatomie, d'Histologie et d'Embryologie." Tome 1, fascicule II. Pétrograde.

1917. Jur. Philiptschenko. Variabilité et hérédité du crâne chez les Mammifères. Hérédité des caractères craniologiques chez les Lapins. Archives Russes. d'Anatomie, d'Histologie et d'Embryologie. Tome 1, fascicule 3. Petrograde.

1912. John C. Phillips. Size inheritance in ducks. Journ. of exp. Zoology Vol. 12. p. 369.

1914. Punnett and Bailey. On inheritance of weight in poultry. Journ. of Genetics Vol. 4, p. 23.

1864. A. Retzius. Ethnologische Schriften. Stockholm.

1923. Walter Scheidt. Einführung in die naturwiss. Familienkunde. J. F. Lehmann's Verlag. Munchen.

1923. E. Schlesinger. Die Kinder der Kinderreichen Familien. Arch. f. Kinderheilk. Bd. 73, S. 50. Ref. in Zentralbl. f. d. ges. Neurol. und Psychiatr. Bd. 34, S. 284.

1923. A. Schreiner. Zur Erblichkeit der Koppform. Genetica V, p. 385.

1915. A. H. Sturtevant. A sex-linked character in Drosophila repleta. Amer. Nat. Vol. 49; p. 189—192.

1918. Szombathy. Ub. relative Schädelmasse und ihre Anwendung. Mitt. d. anthr. Ges. Wien. Bd. 48. 1918.

1918. Szombathy. Tabellen zur Umrechnung der Schädelmasse auf einen Rauminhalt von 1000 Kubikzentimetern (Erg. H. 7 d. mitt. d. Anthr. Ges. Wien 1918.

1912. K. Toyama. On the varying dominance of certain white breeds of the silkworm. Bombyx mori L. Z. f. ind. Abst. und Vererb. l. Bd. 7. p. 252.

1903. E. Tschepourkowsky. Ub. die Vererbung des Kopfindex von Seiten der Mutter. Corr. d.d. Ges. f. Anthr. 34. Ihrg. 1903, S. 172.

1905. E. Tschepourkowsky. Contributions to the study of interracial correlation. Biom IV, p. 286.

Tab. *a*. VARIATION OF THE HEADLENGTHS OF SONS AND DAUGHTERS FROM PARENTS OF DIFFERENT CLASSES OF HEADLENGTH.

No. of the Class.	Parents Dimensions with regard to the mean.	Sons.			Daughters.		
		No.	Mean.	σ.	No.	Mean.	σ.
16	1.2—0.8	23	0.7017	7.19	24	0.721	5.75
14	1.2—0.7	30	0.637	6.61			
12	0.7—0.5	31	0.3055	4.89	34	0.38	4.65
10	0.6—0.5	24	0.395	5.38			
8	0.4	25	0.6	5.91	35	0.369	5.33
6	0.3	29	0.055	6.22	59	0.075	4.49
4	0.2	37	0.203	4.82	40	0.017	5.5
2	0.1	21	−0.048	5.34	23	0.004	3.26
1	0	67	−0.032	5.55	64	−0.023	4.31
3	−0.1	37	−0.292	5.73	33	−0.227	3.5
5	−0.2	21	−0.305	4.52	32	−0.206	4.87
7	−0.3	28	−0.15	5.23	25	−0.12	5.17
9	−0.4— −0.5	29	−0.345	6.64	20	−0.135	5.74
11	−0.4— −0.6	31	−0.503	6.43	23[1])	−0.404	5.67
13	−0.7— −0.9	26	−0.708	7.47	21[2])	−0.562	6.28
15	−0.6— −0.9	28	−0.582	7.23			
low.	−0.3— −0.9	85	−0.507	6.58			
	−0.2— −0.9	122	−0.4	6.38	121[3])	−0.448	5.71
Mediocre.	−0.1—0.1	109	−0.204	5.37	120	−0.058	3.97
	−0.2—0.2	183	−0.089	5.48			
high.	0.2—1.2	145	0.306	6.20	99[4])	0.051	4.92
	0.3—1.2	108	0.401	6.54	93[5])	0.471	5.63
	total	376	−0.006	6.9	433	0.003	5.84

[1]) −0.5— −0.6. [2]) −0.7— −1.2. [3]) −0.2— −1.2. [4]) 0.3 0.2. [5]) 0.4— 1.2.

Tab. *b*. VARIATION OF THE HEADBREADTHS OF SONS AND DAUGHTERS FROM PARENTS OF DIFFERENT CLASSES OF HEADBREATH

No. of the Class.	Parents Dimensions with regard to the mean.	Sons.			Daughters.		
		No.	Mean.	σ.	No.	Mean.	σ.
12	1.3—0.6	34	0.602	4.05	25	0.468	3.22
10	0.5	30	0.394	2.87	34	0.294	4.09
8	0.4	20	0.405	3.51	24	0.208	5.54
6	0.3	35	0.286	4.57	40	0.203	3.90
4	0.2	48	0.037	4.80	41	0.083	3.92
2	0.1	42	–0.012	4.61	47	0.075	3.22
1	0	99	–0.048	4.27	92	–0.026	4.74
3	–0.1	49	–0.208	4.32	49	0.201	4.60
5	–0.2	26	–0.395	3.63	34	–0.38	4.62
7	–0.3	21	–0.324	6.15	27	–0.14	4.61
9	–0.4	31	–0.193	4.44	36	–0.18	4.38
11	–0.5— –0.9	37	–0.638	5.13	31	–0.613	4.03
low.	–0.4— –0.9	68	–0.374	5.22	94[1])	–0.448	4.64
	–0.2— –0.9	115	–0.363	5.47	177[2])	–0.475	4.10
	–0.3— –0.1	96	–0.272	4.10	83[3])	–0.308	4.83
Mediocre.	–0.1—0.1	190	–0.03	4.43	139[4])	0.008	4.25
	0.1—0.2	90	0.015	4.62	88	0.089	3.62
high.	0.3—0.5	85	0.34	3.88	123[5])	0.264	4.13
	0.2—1.3	167	0.3	4.6	164	0.218	4.33
	total	472	–0.012	5.58	480	–0.033	4.84

[1]) –0.3— –0.9. [2]) –0.1— –0.9. [3]) –0.2— –0.1. [4]) 0—0.1. [5]) 0.3—1.3.

Tab. *e*. HEADLENGTHS AND HEADBREADTHS OF CHILDREN 0—20 YEARS OF AGE.

	Boys.					Girls.					Boys.		Girls.	
Age	L.	Relation	B.	Relation	L + B.	L.	Relation.	B.	Relation	L + B.	diff. with L. of adult.	diff. with B of adult.	diff. with L. of adult.	diff with B. of adult.
0	14	1.38	11.5	1.34	25.5	13.7	1.34	11.	1.345	24.7	5.3	3.8	4.65	3.8
0.5	14.9	1.3	12.3	1.25	27.2	14.6	1.26	12.2	1.21	26.8	4.4	3	3.75	2.6
1	16.1	1.2	13.1	1.17	29.2	15.6	1.17	12.9	1.15	28.5	3.2	2.2	2.75	1.9
2	16.8	1.15	13.6	1.13	30.4	16.2	1.14	13.3	1.113	29.5	2.5	1.7	2.15	1.5
3	17.1	1.13	13.7	1.125	30.8	16.5	1.11	13.4	1.1	29.9	2.2	1.6	1.85	1.4
4	17.3	1.12	13.9	1.107	31.2	16.7	1.1	13.6	1.09	30.3	2	1.4	1.65	1.2
5	17.5	1.105	14.2	1.08	31.7	16.8	1.09	13.7	1.08	30.5	1.8	1.1	1.55	1.1
6	17.7	1.09	14.3	1.074	32.	17.9	1.085	13.9	1.065	30.8	1.6	1	1.45	0.9
7	17.8	1.09	14.4	1.07	32.2	17.1	1.07	14	1.057	31.1	1.5	0.9	1.25	0.8
8	17'8	1.09	14.4	1.07	32.2	17.3	1.06	13	1.057	31.1	1.5	0.9	1.05	0.8
9	17.9	1.08	14.5	1.06	32.4	17.4	1.055	14.1	1.05	31.5	1.4	0.8	0.95	0.7
10	18	1.074	14.6	1.053	32.6	17.5	1.05	14.1	1.05	31.6	1.3	0.7	0.85	0.7
11	18	1.074	14.6	1.053	32.6	17.6	1.045	14.2	1.042	31.8	1.3	0.7	0.75	0.6
12	18.2	1.06	14.7	1.047	32.9	17.7	1.04	14.2	1.042	31.9	1.1	0.6	0.65	0.6
13	18.4	1.05	14.8	1.04	33.2	17.8	1.03	14.3	1.035	32.1	0.9	0.5	0.55	0.5
14	18.4	1.05	14.9	1.033	33.3	17.9	1.025	14.4	1.028	32.3	0.9	0.4	0.45	0.4
15	18.5	1.045	14.9	1.033	33.4	18	1.02	14.5	1.02	32.5	0.8	0.4	0.35	0.3
16	18.6	1.04	15	1.026	33.6	18	1.02	14.6	1.014	32.6	0.7	0.3	0.35	0.2
17	18.7	1.034	15	1.026	33.7	18.1	1.014	14.6	1.014	32.7	0.6	0.3	0.25	0.2
18	18.9	1.023	15.1	1.02	34	18.1	1.014	14.7	1.007	32.8	0.4	0.2	0.25	0.1
19	19	1.018	15.2	1.012	34.2	18.2	1.008	14.7	1.007	32.9	0.3	0.1	0.15	0.1
20	19.3	1.002	15.3	1.006	34.6	18.3	1.003	14.8	1	33.1	0	0	0.05	0

M_{lm} = 19.34
M_{bm} = 15.39
L + B = 34.73 (34.6)

M_{lf} = 18.37
M_{bf} = 14.81
L + B = 33.18 (33.1)

Tab. *h*.

L + B in cm.	No of factors.	Index.	Mean Index.	No of factors.
3.7— 3.3	19	14 13	93	19
3.2— 2.8	18	12.5— 11.5	91. 5	18
2.7— 2.3	17	11 — 10	90	17
2.2— 1.8	16	9.5— 8.5	88.5	16
1.7— 1.3	15	8 — 7	87	15
1.2— 0.8	14	6.5— 5.5	85.5	14
0.7— 0.3	13	5 — 4	84	13
0.2— −0.2	12	3.5— 2.5	82.5	12
−0.3— −0.7	11	2 — 1	81	11
−0.8— −1.2	10	0.5— − 0.5	79.5	10
−1.3— −1.7	9	− 1 — − 2	78	9
−1.8— −2.2	8	− 2.5— − 3.5	76.5	8
−2.3— −2.7	7	− 4 — − 5	75	7
−2.8— −3.2	6	− 5.5— − 6.5	73.5	6
−3.3— −3.7	5	− 7 — − 8	72	5
−3.8— −4.2	4	− 8.5— − 9.5	70.5	4
−4.3— −4.7	3	−10 — −11	69	3
−4.8— −52	2	−11.5— −12.5	67.5	2
−5.3— −5.7	1	−13 — −14	66	1

Explanation: For the male the average values are: L = 19.3 cm, B = 15.3 cm, L + B = 34.6 cm; for the female L = 18.3 cm, B = 14.8 cm, L + B = 33.1 cm. We start from these mean values. In heads, of which for the male L + B = 34.6 cm, resp. for the female = 33.1 cm, L + B is represented as o. For large heads we find $L_1 + B_1$ — 34.6 positive and for small heads negative.

Tab. *n*. BRACHYCEPHALIC × DOLICHOCEPHALIC

Index of Parents.	Tables.	Sons.				Daughters.			
		Brachyc.		Dolichoc.		Brachyc.		Dolichoc.	
		Macro	Micro	macro	micro	macro	micro	macro	micro.
mabr × mado	3, 4,13,14,16,17.	18	7	35	5	35	16	32	15
	in %	27.5	11	54	7.5	36	16	33	15
mabr × mido	39,40,41,62,70	4	8	11	14	14	21	7	8
mibr. × mado.	56,47,58,66,73	11	12	12	8	7	16	8	16
mibr. × mido.	28,30,34,35	1	13	5	13	6	15	1	11
	in %	3	40.5	15.5	40.5	18	45.5	3	33.5
br. × do	total	34	40	63	40	62	68	48	50
„	in %	19	23	35.5	22.5	27	30	21	22
„	total	74		103		130		98	
„	in %	42		58		57		43	

Tab. *o*. DOLICHOCEPHALIC × BRACHYCEPHALIC

Index of Parents	Tables.	Sons.				Daughters.			
		Brachyc.		Dolichoc.		Brachyc.		Dolichoc.	
		Macro.	Micro.	macro.	micro.	macro.	micro.	macro.	micro.
mado. × mabr.	8, 8,14,16,17,18	22	7	18	5	29	8	17	7
	in %	42.5	13.5	34.5	9.5	47.5	13	28	11.5
mido. × mabr.	45,46,47,66,73.	6	9	6	7	6	4	7	7
mado. × mibr.	50,51,62,68,70.	10	9	8	10	6	8	5	11
mido. × mibr.	22,23,24,30,31.	2	9	1	11	3	8	2	8
	in %	8.5	39	4.5	48	14.5	38	9.5	38
do. × br.	total	40	34	33	33	44	28	31	33
„	in %	28.5	24	23.5	23.5	32	20.5	23	24
? „	total	74		66		72		64	
„	in %	53		47		53		47	

Tab. *p*. BRACHYCEPHALIC × BRACHYCEPHALIC

Index of Parents.	Tables.	Sons.				Daughters.			
		Brachyc.		Dolichoc.		Brachyc.		Dolichoc.	
		Macro.	Micro.	Macro.	Micro	Macro.	Micro.	Macro.	Micro.
mabr. × mabr.	13,14	14	5	11	2	11	4	11	1
	in %	43.5	16	34.5	6	41	14.5	41	3.5
mibr. × mibr.	28,34,35.	3	4	4	8	5	5	3	6
mabr. × mibr.	40,62,69.	3	11	8	5	9	5	2	6
mibr. × mabr.	66	1	5	1	4	1	3		2
br. × br.	total	21	25	24	19	26	17	16	15
„	in %	23.5	28	27	21.5	35	23	22	20
„	total	46		43		43		31	
„	in %	51.5		48.5		58		42	

Tab. q. DOLICHOCEPHALIC × DOLICHOCEPHALIC.

Index of Parents.	Tables.	Sons.				Daughters.			
		Brachyc.		Dolichoc.		Brachyc.		Dolichoc.	
		Macro.	Micro.	Macro.	Micro	Macro.	Micro.	Macro.	Micro.
mado × mado	4,16,17,18	5	4	3	2	6		4	3
mido. × mido.	30,31	2	5	3	7	1	14	5	9
mado. × mido	68,69,70.	2	2	1	6	3	4	2	2
mido. × mado	47,73.	4	4		6	12	5	5	1
do. × do.	total	13	15	7	21	22	23	16	15
„	in %	23	27	12.5	37.5	29	30	21	20
„	total	28		28		45		31	
„	in %	50		50		59		41	

Tab. r. THE HEADSIZES, OF THE CHILDREN AND OF THE PARENTS.

No of tables.	Children.			Parents.		
	No.	Divergent headsize		No. of fam.	Divergent headsize	
		No.	%		No.	%
1—5	88	95	5.68	20	27	7.11
6—10	100	110	5.79	18	27	
11—14	101	100	5.21	20	35	
15—19	73	100	7.21	14	20	
1—19	362	405	5.89	72	109	8
20—24	43	39	4.77	8	11	
25—28	93	100	5.66	18	32	
29—31	66	82	6.54	10	12	
32—35	94	118	6.61	16	24	
20—35	296	339	6.03	52	79	8
1—35	658	744	5.95	124	188	8
36—42	85	100	6.19	17	45	13.93
43—48	60	85	7.46	10	37	
49—52	30	56	9.82	6	17	
53—59	103	109	5.57	18	50	
60—62	78	104	7.02	14	38	
63—66	36	47	6.87	8	32	
67—71	54	85	8.28	9	22	
72—74	45	66	7.72	8	16	
36—74	491	652	6.99	90	257	15.03

N. of family	Head values	Grandfather father's side	Grandmother father's side	Grandfather mother's side	Grandmother mother's side	Father	Mother	Chi Sons 1	2	3	4	5	6	7
377	L	19	17.4	20.2	17.8	18.8	19.2[1])	18.3	17.1					
	B	16.1	14.6	15.2	14.7	17.4	14.85	14.2	14.3					
	Ind	84.2	84	75.2	82	92.8	77.3	77.6	83.6					
377	L					20.2	17.8							
a	B					15.2	14.7							
	Ind					75.2	82							
377	L			19	17.4	18.9	17.7	17.7	19.8	19.3				
b	B			16.1	14.6	14.8	15.1	15.2	15.2	15.4				
	Ind			84.2	84	78.3	85.8	85.8	76.6	79.7				
377	L					19	17.4	18.3						
c	B					16.1	14.6	17.4						
	Ind					84.2	84	92.8						
378	L	19.7	20.4	20.5	17.8	19.6	18.4							
	B	15.9	15.3	16.7	15.5	15.4	15.9							
	Ind	80.7	75.2	81.4	87.1	78.6	86.4							
378a	L					20.5	17.8							
	B					16.7	15.5							
	Ind					81.4	87.1							
378b	L					19.7	20.4	19.5	19.6	20.4				
	B					15.9	15.3	15.6	15.4	15.6				
	Ind					80.7	75.2	80	78.6	76.5				
378	L			20.5	17.8	18.2	18.8	17.1						
c	B			16.7	15.5	15.8	14.7	14.8						
	Ind			81.4	87.1	86.5	78.4	86.5						
379a	L	20	18	20	18.7	19.6	17.9	16.8	17.4					
	B	17.1	15.1	16.2	15.9	16.1	14.9	14.2	13.5					
	Ind	85.2	84	81	85	82.3	83.2	84.5	77.6					
379b	L					20	18.7	19.7						
	B					16.2	15.9	15.5						
	Ind					81	85	78.7						
379	L			20	18.7	19.4	17.9							
c	B			16.2	15.9	15.2	15							
	Ind			81	85	78.2	83.7							

[1]) sister of mother 18.8, 15, 79.5.

T OCCUR IN THE TABLES OF 1921c

n	Daughters				Ages of sons and of daughters
1	2	3	4	5	
.7	16.4				9, 4
.6	13.5				12, 5
.8	82.5				
.2	18.8				
.8	15				adult
.3	79.5				
.6	17.5				19, 18
.9	13.8				10, 6
	79.2				
.7					adult
.2					adult
.8					
.3[1])	15.6				
.7	12.5				10m, 10m
	80				
.8	18.4				
.7	15.9				adult
.4	86.4				
					adult
.1					6
.2					9
.7					
					4, 1.75
.9	17.9	18.7			adult
	14.9	15.1			adult
.7	83.2	80.9			
.4					
.8					11

nd measurement, 3 yrs of age 16, 13.9, 87.

N. of family	Head values	Grandfather father's side	Grandmother father's side	Grandfather mother's side	Grandmother mother's side	Father	Mother	Ch						
								Sons						
								1	2	3	4	5	6	
379	L	20	18			19.6	18.1	17.1						
d	B	17.1	15.1			16.1	14.7	14.1						
	Ind	85.2	84			82.1	81.2	82.4						
379	L					20	18	19.6	19.6					
e	B					17.1	15.1	16.1	16.1					
	Ind					85.2	84	82.3	82.1					
380	L					20.4	18.7							
a	B					14.2	15.5							
	Ind					70	82.5							
380	L			20.4	18.7	19.3	19.1	18.4	18.1	17.7	17.3	18.1[1]	17.6	13.
b	B			14.2	15.5	16	14.6	14.9	14.8	14.4	13.9	15.2	14	11.
	Ind			70	82.5	82.9	76.8	81	81.7	81.3	80.3	84	79.5	85
380	L					20.2	18.7	19.2	20.2	19.4				
c	B					15.9	14.3	15	15.1	15.6				
	Ind					78.7	76.3	77.9	74.8	80.3				
380	L	20.2	18.7	20.4	18.7	19.4	19.1	18.2	17.7					
d	B	15.9	14.3	14.2	15.5	15.6	14.1	15.2	14.4					
	Ind	78.7	76.3	70	82.5	80.3	74.2	83.5	81.2					
380	L			20.2	18.7	19.7	18.7	18.5	17					
e	B			15.9	14.3	16.6	14.5	15	13.3					
	Ind			78.7	76.3	84.3	77.8	81	78.7					
380	L	19.8	16.8	20.2	18.7	19.1	18.8	16						
f	B	15.4	14.7	15.9	14.3	15.1	15.1	13.8						
	Ind	78.2	87.7	78.7	76.3	81.2	80.3	86.2						
380	L					19.8	16.8	19.1	19.4					
g	B					15.4	14.7	15.1	15.1					
	Ind					78'2	87.7	81.2	78.8					
380	L	20.2	18.7			19.2	18.1	17.3	16					
h	B	15.9	14.3			15	14.9	14.7	14.3					
	Ind	78.7	76.3			77.9	82.2	84.7	89.5					
380	L	20.2	18.7	20.4	18.7	20.2	18.7							
j	B	15.9	14.3	14.2	15.5	15.1	14.3							
	Ind	78.7	76.3	70	82.5	74.8	76.4							

[1]) rachitis. [2]) 2nd meas. 0.5 yr later 14.8, 13.2, 88.

)T OCCUR IN THE TABLES OF 1921c

·n					
	Daughters				Ages of sons and of daughters
1	2	3	4	5	
16.6					4.5
13.6					6.5
81.9					
					adult
18.7	19.1	19.1	19.6	18.7	
14.3	14.6	14.1	14.4	15.3	40, 38, 34, 33, 27
76.4	76.8	74.2	73.5	81.8	
17.4	16.7[3])				12, 9, 8, 7, 6, 4, 4m.
14	13.8				14, 2.
80.4	82.6				
18.7	18.8	20.2			42, 40, 37
14.5	15.1	15.7			35, 32, 28
77.8	80.3	78			
15.8					11, 8
13.5					3
85.4					
17.4	17.5				6, 1.5
14.2	13.4				8, 5
81.6	76.3				
16.4					1, 3
14.2					3
86.7					
18					32, 30
14.5					14
80.5					
17.6	17.1	16.7	16.3	13.6	8, 2
14.2	14.1	14.2	14.1	11	9, 8, 6, 3, 4m.
80.7	82.2	84.7	81.2	80.8	
18.5	18.4	17.8	18.3	17.5	
14.9	14.8	14.2	14.2	14.9	15, 14, 13, 12, 11.
80.8	80.6	79.8	77.6	85.3	

[3]) 2nd meas. 0.5 yr later 17, 14.1, 82.9.